TMDL Water Quality Study of the Middle and Lower Sevier River Watershed

DRAFT

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1.0 INTRODUCTION

The Sevier River watershed is located in central and southwestern Utah (Figure 1-1). The principal drainage in the watershed is the Sevier River and its larger tributaries: the East Fork of the Sevier River, Salina Creek, and the San Pitch River. These tributaries and other smaller streams flowing from the surrounding hills and valley-floor springs discharge into the Sevier River. The Sevier River, in turn, drains into Sevier Lake, a normally dry playa lake.

The Sevier River watershed covers nearly 11,000 square miles of land with significant variations in topography, climate, soils, and vegetation. Elevations range from approximately 4,500 feet to 12,000 feet with annual precipitation ranging from 8 inches to 35 inches. The geologic parent materials provide a wide variety of soils producing vegetation ranging from alpine conifer forest to desert shrubs and grasses.

Section 303(d) of the Clean Water Act and the U.S. Environmental Protection Agency's (EPA's) Water Quality Planning and Management Regulations (40 CFR Part 130) require states to develop Total Maximum Daily Loads (TMDLs) for water bodies that are not meeting applicable water quality standards/guidelines or designated uses under technology-based controls. TMDLs specify the maximum amount of a pollutant which a waterbody can receive and still meet water quality standards. Based upon a calculation of the total load that can be received, TMDLs allocate pollutant loads to sources and a margin of safety (MOS). This study determines allowable limits for pollutant loadings to meet water quality standards and designated uses in the middle and lower Sevier River watersheds. Separate reports have been developed to address TMDL issues in other parts of the basin. Pollutant load reductions are allocated among the significant sources and recommendations are made for implementation activities that will result in the identified load reductions. In this way, the TMDL process links the development and implementation of control actions to the attainment and maintenance water quality standards and designated uses.

In Utah, the development of TMDLs is integrated within a larger watershed management framework that emphasizes a common-sense approach aimed at protecting and restoring water quality. Key elements of this approach include:

?? Water quality monitoring and assessment
?? Local stakeholder leadership
?? Problem targeting and prioritization
?? Integrated solutions that coordinate multiple agencies and interest groups.

The development of the Sevier River TMDLs has been conducted with these key elements in mind. The technical analysis has been based primarily on a wealth of water quality monitoring data collected by the Utah Division of Water Quality as well as the U.S. Geological Survey. The Sevier River Steering and Technical Advisory Committee has been involved with the development of the TMDL and will be taking the lead on implementing a variety of the identified best management practices. Due to the large scale of the watershed and the complexity of the issues, the Committee will also be assisting the DWQ with problem targeting and prioritization of solutions, especially for nonpoint sources. Other agencies that will be involved in identifying solutions in the watershed include the Natural Resources Conservation Service (NRCS), the Bureau of Land Management (BLM), and the local municipalities and landowners.

Section 2.0 of this document presents the water quality standards that apply to the listed segments in the middle and lower Sevier River watersheds. Water quality standards are integral to the TMDL process because they represent the targets by which water quality is measured. Section 3.0 presents a general overview of the most significant pollutant sources in the Sevier River watershed and Section 4.0 describes the technical approach that was used to quantify existing and allowable pollutant loads. Section 5.0 provides a detailed analysis of the available water quality data for each segment, presents the results of the TMDL allocations, and includes segment-specific recommendations for implementation. Section 6.0 documents how a margin of safety and seasonality were incorporated into the analysis and Section 7.0 further discusses implementation strategies. Recommendations for future monitoring and the results of the public participation activities are discussed in Section 8.0 and 9.0, respectively.

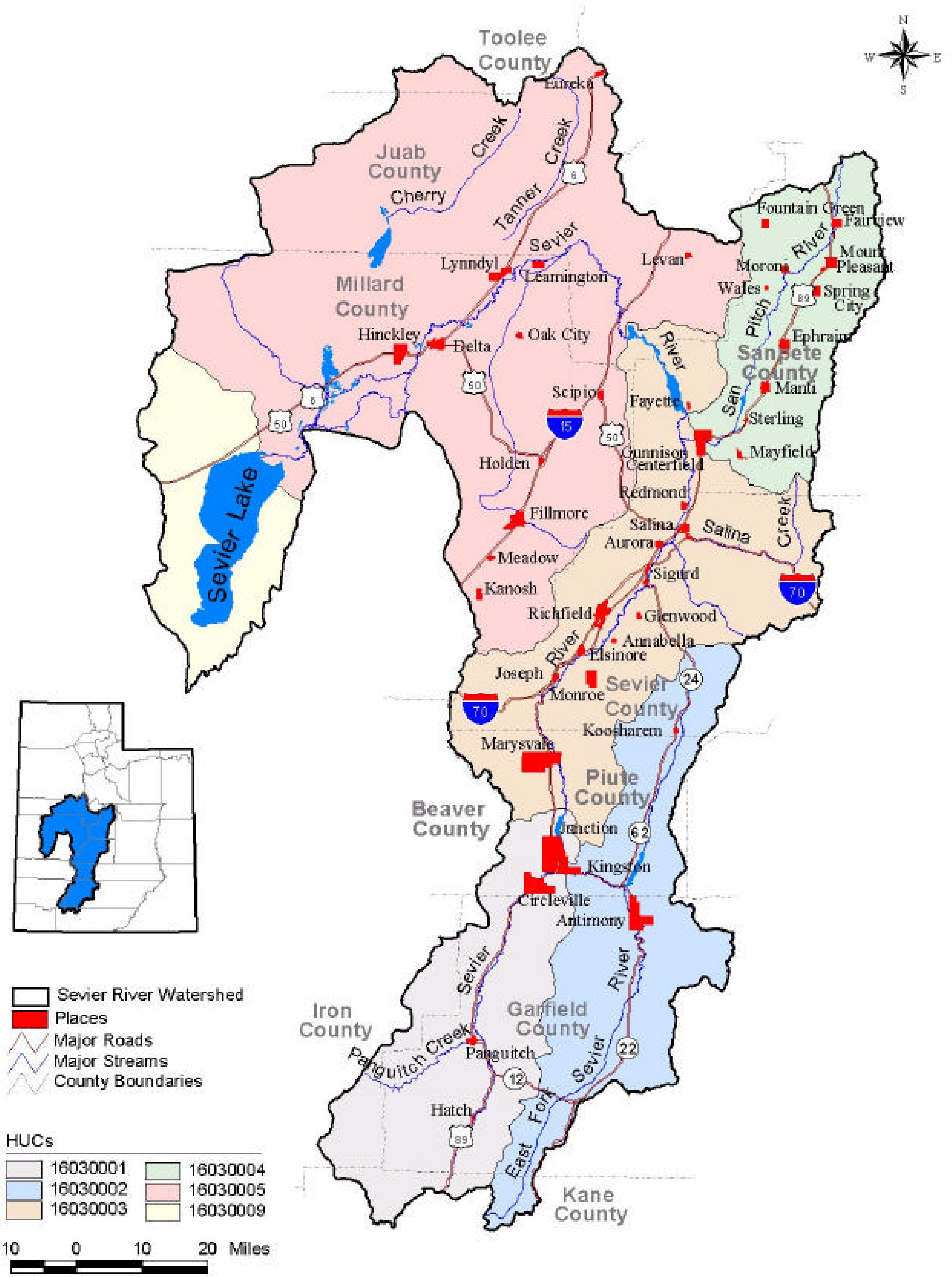

Figure 1-1. Location of the Sevier River watershed.

2.0 WATER QUALITY STANDARDS AND TMDL TARGETS

This section of the document first presents the 303(d) list status of all listed waterbodies within the watershed followed by a description of the parameters of concern, the applicable water quality standards, and the water quality targets for the TMDL.

2.1 303(d) List Status

Various segments of the Sevier River appear on the state of Utah's 2002 Section 303(d) list of impaired waters. Causes of impairment include total dissolved solids, sediment, and total phosphorus (UDEQ, 2002). The beneficial uses that are impaired include 2B, 3B, and 4 (see Table 2-1 and Figure 2-1). The Clean Water Act requires that states develop TMDLs for waters appearing on a state's section 303(d) list. A TMDL is the maximum amount of a particular pollutant that a waterbody can receive and still attain water quality standards.

Table 2-1. Information for the 2002 Section 303(d) listed segments in the Sevier River watershed.

Name	Beneficial Use Class	Cause of Impairment	8-Digit HUC
Sevier River (Rocky Ford Reservoir to the Annabella Diversion)	4	Total Dissolved Solids	16030003
Sevier River (Yuba Dam to the confluence with Salina Creek)	2B, 3B, 4	Total Dissolved Solids, Sediment, Total Phosphorus, Habitat Alteration	16030003
Sevier River (U-132 crossing to Yuba Dam)	2B, 3B, 4	Sediment, Total Phosphorus, Habitat Alteration	16030005
Sevier River (DMAD Reservoir to U-132 crossing)	2B, 3B, 4	Total Dissolved Solids, Sediment, Total Phosphorus, Habitat Alteration	16030005
Sevier River (Gunnison Bend Reservoir to DMAD Reservoir)	3B, 4	Total Dissolved Solids, Sediment, Habitat Alteration	16030005
Sevier River (Crear Lake to Gunnison Bend Reservoir)	4	Total Dissolved Solids	16030005
Sevier River tributaries (East side tributaries from the Rocky Ford Reservoir to the Annabella diversion below the USFS boundary)	4	Total Dissolved Solids	16030003
Salina Creek (Confluence with the Sevier River to the USFS boundary)	4	Total Dissolved Solids	16030003
Lost Creek and tributaries (Confluence with the Sevier River upstream)	4	Total Dissolved Solids	16030003
Chicken Creek (confluence with the Sevier River to Levan)	4	Total Dissolved Solids	16030005
Peterson Creek	4	Total Dissolved Solids	16030005

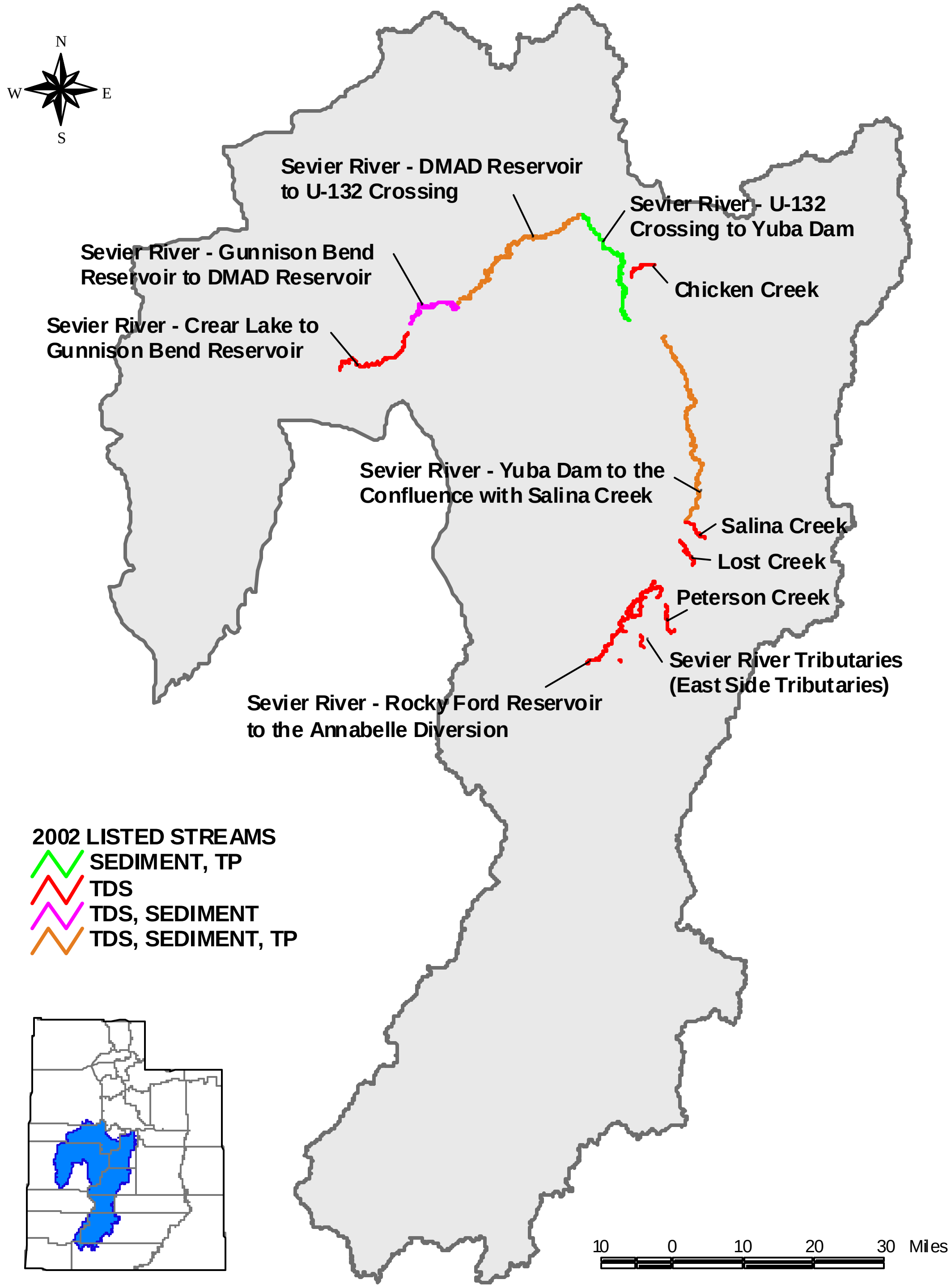

Figure 2-1. 303(d) Impaired waters in the Sevier River watershed.

2.2 Parameters of Concern

The following sections provide a summary of the parameters identified on the Utah 2002 303(d) list as causing impairments in the Sevier River watershed. The purpose of these sections is to provide an overview of the parameters, units, sampling methods, and potential sources for these parameters for those readers who might not be familiar with them. The relevance of each parameter to the various beneficial uses is also briefly discussed.

2.2.1 Total Dissolved Solids

As water flows through a system, particles of soil, rock, and other materials accumulate in the water. The materials dissolve (or dissociate) in the water to form cations (positively charged ions) and anions (negatively charged ions). The term *salinity* refers to the total amount of dissolved cations and anions in water. Major ions in water are generally sodium, calcium, magnesium, potassium, chloride, sulfate, and bicarbonate. Metals (e.g., copper, lead, and zinc) and other trace elements (e.g., fluoride, boron, and arsenic) are usually only minor components of the total salinity. Salinity is determined by measuring the *conductance* of water, which is the opposite of resistance. This is done by sending an electrical current through the water and measuring the *electrical conductivity* (EC). The conductance of the water is corrected to a water temperature of 25 °C, and is sometimes then called *specific conductivity* (SC).

The sum of all of the dissolved substances in water is called *total dissolved solids* (TDS), and is measured in milligrams per liter (mg/L). TDS is a laboratory measurement and cannot be determined in the field. Pure distilled water has a TDS of zero. TDS concentrations in rainfall and snowfall vary, and generally range from zero to 10 milligrams per liter (mg/L). In comparison, the average TDS for the lower segment of the Sevier River at the U-257 crossing in Deseret is 2,440 mg/L.

The salinity of a waterbody is important to many aquatic organisms because it regulates the flow of water into and out of an organism's cells (osmosis). Increases or decreases in salinity can cause a shift in the composition of the natural aquatic community. In the Sevier River, it is likely that many native aquatic organisms have adapted to the natural moderate salinity. However, highly saline waters can also adversely affect crop production depending on the amount of water applied and the salt tolerance of the crop. Livestock can also be adversely affected by high salinity values.

Natural sources, such as geology and soils, contribute to the salinity of a stream. Watersheds that have easily erodible soils, or parent materials with high salt concentrations, have streams and lakes that have naturally high salinity. However, there are also several potential anthropogenic sources of salinity. Anthropogenic sources of salinity can occur from agricultural irrigation returns, disturbed land, road salting, and agricultural runoff.

2.2.2 Total Phosphorus

Total phosphorus is a nutrient necessary to sustain aquatic life. The natural amount of total phosphorus in a waterbody varies depending on the type of system. A pristine mountain spring might have little to almost no total phosphorus, whereas a lowland, mature stream flowing through wetland areas might have naturally high total phosphorus concentrations. Various forms of phosphorus can exist at one time in a waterbody, although not all forms can be used by aquatic life. Common phosphorus sampling parameters are total phosphorus (TP), dissolved phosphorus, and orthophosphate. Concentrations are measured in the lab and are typically reported in milligrams per liter.

Total phosphorus generally does not pose a direct threat to the beneficial uses of a waterbody. However, excess phosphorus can cause an undesirable abundance of plant and algae growth. This process is called eutrophication or nutrient enrichment. Nutrient enrichment can have many detrimental effects on water quality. One possible effect of eutrophication is low dissolved oxygen concentrations. Aquatic organisms need oxygen to live and they can experience lowered reproduction rates and mortality with lowered dissolved oxygen concentrations. Recreational uses can also be impaired because of eutrophication. Nuisance plant and algae growth can interfere with swimming, boating, and fishing. Excess nutrients generally do not pose a threat to agricultural uses.

It should be noted that the impact of nutrient concentrations are moderated by riparian habitat conditions. Vegetated riparian buffers are a vital functional component of stream ecosystems and are instrumental in the detention, removal, and assimilation of nutrients from or by the water column. A stream with good riparian habitat is thus better able to moderate the impacts of high nutrient loads than is a stream with poor habitat. High nutrient concentrations in the Sevier River watershed are therefore compounded by the fact that the natural habitat of many of the streams has been altered.

Phosphorus exists in rocks and soils and is naturally weathered and transported into waterbodies. Organic matter is also a natural source of nutrients. Systems rich with organic matter (e.g., wetlands and bogs) can have naturally high nutrient concentrations. Phosphorus is also potentially released into the environment through different anthropogenic sources including septic systems, wastewater treatment plants, fertilizer application, and animal feeding operations.

2.2.3 Sediment

Excess total suspended solids (TSS) in a stream can pose a threat to aquatic organisms. Turbid waters created by excess TSS concentrations reduce light penetration, which can adversely affect aquatic organisms. Also, TSS can interfere with fish feeding patterns because of the turbidity. Prolonged periods of very high TSS concentrations can be fatal to aquatic organisms (Newcombe and Jensen, 1996). TSS can also pose a threat to recreational uses because of murky conditions and muddy stream bottoms. High levels of TSS in irrigation waters can clog irrigation ditches and drainage pumps.

As TSS settles to the bottom of a stream, critical habitats such as spawning sites and macroinvertebrate habitats can be covered in sediment. This is referred to as siltation or substrate embededness. Excess sediment in a stream bottom can reduce dissolved oxygen concentrations in stream bottom substrates, and it can reduce the quality and quantity of habitats for aquatic organisms.

Erosion and overland flow contribute some natural TSS to most streams. In watersheds with highly erodible soils and steep slopes, natural TSS concentrations can be very high. Excess TSS in overland flow can occur when poor land use and land cover practices are in place. This potentially includes grazing, row crops, construction activities, road runoff, and mining. Grazing and other practices that can degrade stream channels are other possible sources of TSS. Utah currently has a water column criterion for TSS of 90 mg/L for the protection of warm water aquatic life.

2.2.4 Habitat Alterations

Several of the stream segments in the Sevier River watershed are listed as impaired due to habitat alterations. Habitat alterations refer to a variety of anthropogenic impacts that have lead to a change in the riparian corridor compared to historic conditions. These include flow alterations caused by dams and irrigation diversions; substrate embeddedness caused by streambank and land erosion; loss of riparian vegetation due to livestock grazing; and channel instability caused by streambank modification.

Due to the nature of the TMDL process, with its focus on “loads”, it is not entirely appropriate to develop a “habitat TMDL”. Instead, habitat improvements are typically targeted by selecting best management practices that result in both load reductions to pollutants (such as sediment) and habitat improvements. For example, fencing of a stream corridor not only removes a potential load but also provides for significant habitat improvements because it allows re-vegetation to occur.

2.3 Applicable Water Quality Standards

The Utah Water Quality Board (UWQB) is responsible for creating water quality standards that are then enforced by the Utah Department of Environmental Quality, Division of Water Quality. UWQB has established numeric water quality standards for TDS and a pollution indicator value for TP. These standards are found in the Utah Administrative Code, Standards of Quality for Waters of the State R317-2 and vary based on the beneficial use assignment of the waterbody (UDEQ, 2001).

UWQB had am established numeric water quality standard of 90 mg/L for TSS when this study was initiated, but this standard has since been dropped. The 90 mg/L value was therefore used to develop these TMDLs but no longer has the same regulatory requirements that it did previously. The 90 mg/L is labeled an "interim water quality target" in this document and should be revised in the future as our understanding of natural sediment conditions in the Sevier River continues to build.

Table 2-2 summarizes the TMDL targets pertaining to the 303(d) listed segments in the Sevier River basin.

Table 2-2. TMDL targets for streams in the Sevier River basin.

Designated Use	Description	TSS Interim Water Quality Target	TDS Numeric Standard	TP Pollution Indicator
2B	Secondary contact recreation	?	?	0.05 mg/L (max)
3B	Warm water aquatic life	90 mg/L (max)	?	0.05 mg/L (max)
4	Agricultural use	?	1200 mg/L (max)	?

The beneficial use support status for streams in Utah is determined using the water quality criteria shown in Table 2-2. Utah has determined guidelines for assessing each beneficial use. The guidelines for assessing class 3 aquatic life uses are shown in Table 2-3 and the guidelines for assessing class 4 agricultural uses are shown in Table 2-4 (UDEQ, 2002).

Table 2-3. Criteria for assessing aquatic life beneficial use support classes 3A, 3B, and 3C for total phosphorus and sediment.

Degree of Use Support	Classification Criteria
Full	For any one pollutant, no more than one exceedance of criterion or criterion was not exceeded in < 10% of the samples if there were 2 or more exceedances
Partial	For any one pollutant, criterion was exceeded 2 times, and criterion was exceeded in more than 10% of the samples but not more than 25% of the samples
Non	For any one pollutant, criterion was exceeded 2 times, and criterion was exceeded in more than 25% of the samples

Table 2-4. Criteria for assessing agricultural beneficial use support class 4 for total dissolved solids.

Degree of Use Support	Classification Criteria

Full	Criterion was exceeded in less than 2 samples and in <10% of the samples if there were 2 or more exceedances
Partial	Criterion was exceeded 2 times, and criterion was exceeded in more than 10% but not more than 25% of the samples
Non	Criterion was exceeded 2 times, and criterion was exceeded in more than 25% of the samples

2.3.1 Total Phosphorus Pollution Indicator

The 0.05 mg/L indicator for total phosphorus is based on a narrative criterion rather than a numeric one and therefore there is flexibility with regard to identifying a site-specific value. As explained above nutrients rarely approach concentrations in the ambient environment that are toxic to aquatic life except under unusual circumstances. However, nutrients, while essential to the functioning of healthy aquatic ecosystems, can exert negative effects at much lower concentrations by altering trophic dynamics, increasing algal and macrophyte production, increasing turbidity (via increased phytoplankton algal production), decreasing average dissolved oxygen concentrations, and increasing fluctuations in diel dissolved oxygen and pH. Such changes are caused by excessive nutrient concentrations resulting in shifts in species composition away from functional assemblages of intolerant species, benthic insectivores and top carnivores typical of high quality warmwater streams towards less desirable assemblages of tolerant species, niche generalists, omnivores, and detritivores typical of degraded warmwater streams.

Utah's statewide indicator of 0.05 mg/L is within the range of most phosphorus criteria recommended by other states and is believed to be a good target in the absence of more site-specific information. To assess the potential for a site-specific value for the Sevier River watershed the available benthic macroinvertebrate data were reviewed. Benthic macroinvertebrates are excellent indicators of water quality conditions because they integrate the impact of individual short-term events with the more frequently occurring conditions present under normal flows. The type and numbers of various macroinvertebrates can be used to calculate a biological score that can be used to assess the biological integrity goal of the Clean Water Act. More and more states are beginning to use biological scores and biocriteria to determine the impairment status of their rivers and streams.

Macroinvertebrate data were downloaded from STORET for the three existing sites on the Sevier River and the data are presented in Table 2-5. The results of the data assessment indicate the following:

?? Station 494247: The organisms that are most dominant in this sample are relatively pollution tolerant and often respond positively to nutrients (Hydropsyche [net-spinning caddis], Orthocladiinae [midges], Simuliidae [blackflies], and Tubificidae [sludge worms]). The average TP concentration at this station is 0.16 mg/L.

?? Station 494258: The organisms at this station are similar to those observed at station 494247 (i.e., pollutant tolerant and nutrient responsive). The average TP concentration at this station is 0.14 mg/L.

?? Station 494760: The data for this station do not follow a predictable relationship. Some organisms that are very abundant in the first or second year of sampling are almost completely absent in latter years or vice versa (e.g., Chironomini, Orthocladiinae, Corydalidae, Tubificidae). This raises the possibility of taxonomic error because these kinds of differences are almost never this stark. Of the organisms that are relatively abundant, many are pollution tolerant and nutrient responsive. The average TP concentration at this station is 0.09 mg/L.

Based on these results there does not appear to be a compelling reason to modify the 0.05 mg/L total phosphorus pollution indicator. Existing biological conditions at these three stations indicate impairment, which is consistent with the observed total phosphorus concentrations exceeding the 0.05 mg/L target. Unfortunately, no data exist for unimpaired stations to suggest what a more appropriate target should be. The TMDLs for the Sevier River will therefore be based on the existing 0.05 mg/L pollution indicator.

Table 2-5. Species composition (in #/m^2) for the various stations with data on the Sevier River.

	494760 (Sevier River below Rocky Ford Reservoir)			494258 (Sevier River west of Gunnison)	494247 (Sevier River Above Yuba Reservoir and southwest of Gunnison)
Species	5/9/1996	11/19/1996	4/15/1997	4/16/1997	11/19/1996
Acarina					258
Ambrysus	18	8			
Anax					
Antocha monticola			8		
Arctopsyche grandis	11	43			
Argia	11		11	30	43
Asellus	18		8		
Baetis	219	8			
Bezzia		3		11	215
Brychius				11	
Calopterygidae			3	19	
Chelifera		1717	8	51	43
Chironomini	1166				
Cinygmula	14	11	16		
Coenagrionidae	18	11	16		22
Copepoda	14				22
Corydalidae	1475				
Decapoda		81	3	3	
Dubiraphia				43	
Dytiscidae			46		
Elmidae	36			129	43
Empididae	14				
Gastropoda	18				
Glossosoma	14				
Haliplidae					43
Helobdella				32	
Hemerodromia	7				22
Heptagenia	32				
Hexatoma		22			22
Hyalella azteca	43	16	132	872	108
Hydropsyche			110	2457	8051
Hydroptila	29		43	30	1206
Isoperla				65	
Lumbricidae				11	
Mayatrichia					43
Naucoridae		8	8		
Nectopsyche	11			32	
Nematoda					22
Oligochaeta		8			151
Ophiogomphus				19	
Orthocladiinae			5005	5866	6437

Species	494760 (Sevier River below Rocky Ford Reservoir)			494258 (Sevier River west of Gunnison)	494247 (Sevier River Above Yuba Reservoir and southwest of Gunnison)
	5/9/1996	11/19/1996	4/15/1997	4/16/1997	11/19/1996
Ostracoda					43
Physa				8	
Planaria	18	48			22
Simuliidae			13	1052	5791
Stratiomyidae			3		
Tanypodinae	7		3	401	194
Tipulidae		30		8	
Tricorythodes minutus	187	439	75	148	129
Tubificidae	4173	3	57	1001	3447
Zaitzevia			8		215

3.0 SOURCE ASSESSMENT

A field assessment of the Sevier River watershed was conducted during the week of October 14, 2002 to obtain a better understanding of the potential pollutant sources. The assessment was performed from the Annabella Diversion to Sevier Lake. Potential pollutant sources were identified and located using a GARMIN 3+ global positioning system (GPS) with up to five-foot accuracy. These sources included animal feeding operations (AFOs), lagoons, industrial sources, areas of land disturbance, streambank erosion, agricultural practices, and natural sources. The immense scale of the watershed precluded a comprehensive assessment of each source. However, Table 3-1 summarizes the results of the field assessment and each source category is described in the remainder of this section of the report. Section 4 provides a description of the methodology by which the magnitude of the source loadings were evaluated and Section 5 presents the results of the analysis.

Table 3-1. Summary of sources of impairment in the lower Sevier River watershed.

Name	Parameter	Sources
Rocky Ford Reservoir to the Annabella Diversion	TDS	Geology, Evaporation, Cumulative Effects
Yuba Dam to the confluence with Salina Creek	TDS	Geology, Irrigation, Evaporation, Cumulative Effects
	Sediment	Streambank Erosion, Land Erosion, Mining
	Total Phosphorus	Feedlots, Lagoons, Irrigation, Cumulative Effects
U-132 crossing to Yuba Dam	Sediment	Streambank Erosion, Land Erosion, Grazing
	Total Phosphorus	Feedlots, Cumulative Effects, Irrigation
DMAD Reservoir to U-132 crossing	TDS	Irrigation, Cumulative Effects, Geology
	Sediment	Streambank Erosion, Land Erosion, Grazing
	Total Phosphorus	Feedlots, Cumulative Effects, Irrigation
Gunnison Bend Reservoir to DMAD Reservoir	TDS	Irrigation, Cumulative Effects, Evaporation
	Sediment	Streambank Erosion, Land Erosion
Crear Lake to Gunnison Bend Reservoir	TDS	Irrigation, Cumulative Effects
Salina Creek from the Confluence with the Sevier River to the USFS boundary	TDS	Geology, Irrigation
Lost Creek and tributaries	TDS	Geology
Chicken Creek from the Sevier River to Levan	TDS	Geology, Irrigation, Evaporation
East side Sevier River tributaries from the Rocky Ford Reservoir to the Annabella diversion (below the USFS boundary)	TDS	Geology, Irrigation
Peterson Creek	TDS	Geology

3.1 Geology

The Sevier River watershed contains a variety of geologic formations consisting of sedimentary, igneous, and metamorphic rocks. One particular sedimentary formation of interest because of its high salinity and erodibility is the Arapien Shale formation. Arapien Shale was formed during the Middle Jurassic period from marine deposits. Witkind's (1994) description of the Arapien Shale is summarized below.

The Arapien Shale consists of a sequence of beds of calcareous mudstone, gypsiferous shale, siltstone, fine-grained sandstone, and sparse limestone. Most of the units are so soft that the formation tends to form badland topography marked by intricately dissected low hills and ridges separated by narrow, sinuous valleys. Thin to thick beds of evaporite, chiefly rock salt (halite), gypsum, anhydrite, and calcite are integral parts of the formation.

Arapien Shale near Richfield, Utah.

In the Sevier River valley, the Arapien Shale formation consisted of mottled red, gray, and white rolling hills that are easily eroded and have little vegetation. Arapien Shale hills near Salina Creek are barren and easily eroded, and gypsum crystals can be observed at the soil surface. Soils formed from this shale often have a white frosted appearance because of salt deposits.

The Arapien Shale formation is present at the soil surface in several areas in the Sevier River and San Pitch River valleys (Figure 3-1). It is a potential natural source of salinity in streams for the entire lower Sevier River watershed and especially for the Sevier River, Lost Creek, Chicken Creek, and the Sevier River tributaries located east of the Sevier River from Richfield to Levan. Witkind (1994) noted that salt contained in the Arapien Shale formation is not generally present at the surface, which is probably due to the fact that the salt is quickly eroded when exposed. Noted salt outcroppings in the formation are present near Redmond and throughout the Salina Creek Canyon.

Two types of industry are dependant on the Arapien Shale found in the Sevier River watershed. A gypsum mining operation and drywall factory are located just upstream and east of the Rocky Ford Reservoir. The gypsum is mined from a large Arapien Shale formation east of the Sevier River. Also, table salt is mined and refined at the Redmond Salt mine near Redmond, Utah.

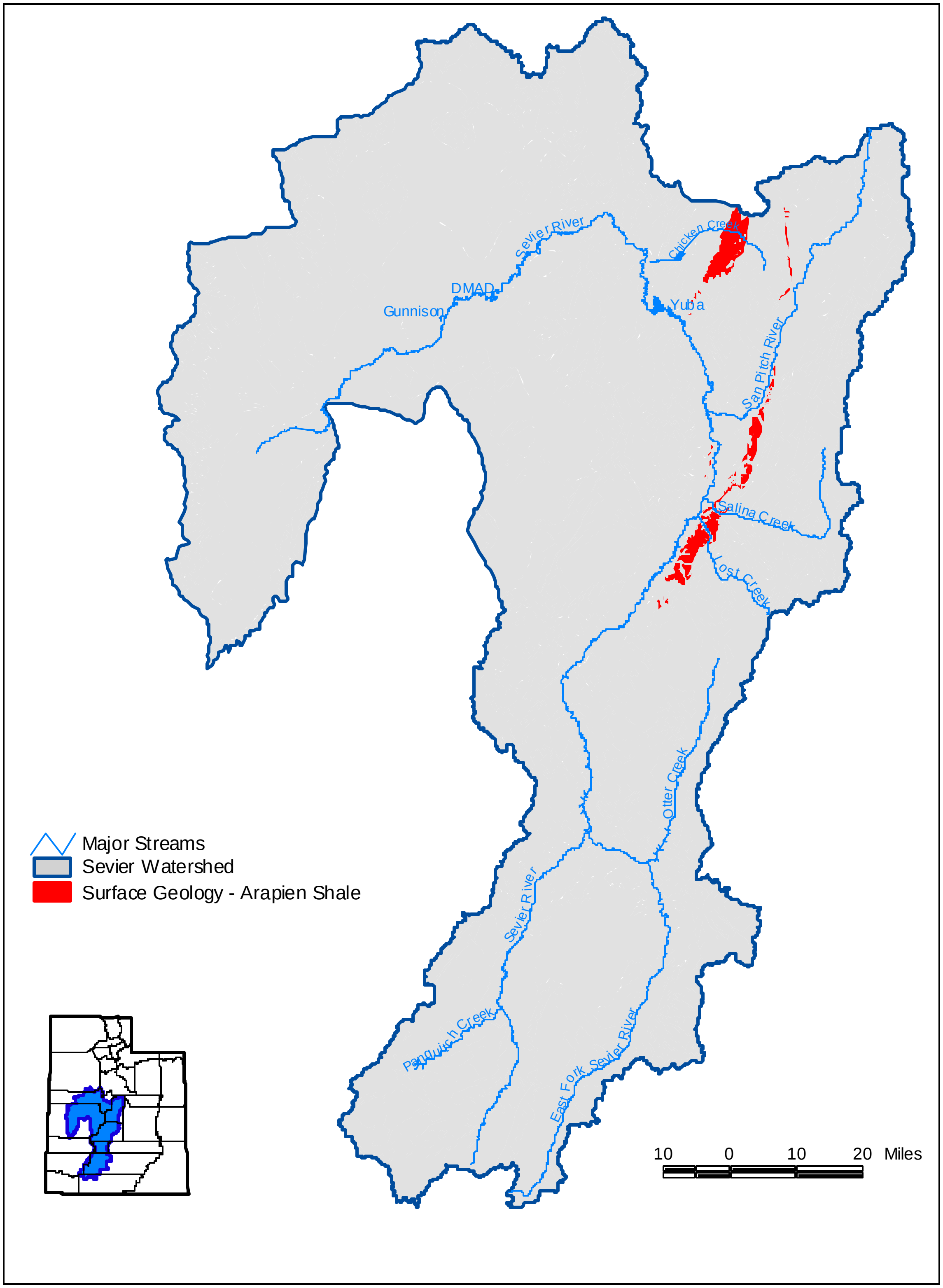

Figure 3-1. Potential Arapien shale areas in the Sevier River watershed.

3.2 Animal Feeding Operations

Almost all of the Sevier River Valley downstream from the Annabella Diversion is used for agriculture. Most of the land is used for grazing or crops are grown for livestock. Table 3-2 provides the most recent Agricultural Census livestock data for the counties in the Sevier River watershed. During the field assessment, major animal feeding operations (AFOs) were located and recorded with the GPS unit and are shown in Figure 3-2. While twenty-seven AFOs were documented during the field assessment, Table 3-3 and Table 3-4 indicate that more than 200 AFOs were found during a detailed inventory conducted by the Utah Farm Bureau. Additional information on the numbers of livestock were provided by local landowners and NRCS officials. These data are summarized in Table.

Animal feeding operation next to the Sevier River.

On average, livestock are assumed to spend one-half of the year in the wet meadow pastures with access to the river and the rest of the year they are either on the forest or concentrated in corrals. Poor management practices, including feedlot runoff, overgrazing, poor manure management, and grazing in and around streams, can contribute to water quality problems and were observed at several operations during the TMDL field visit.

Table 3-2. Livestock information available from the 1997 U.S. Department of Agricultural Census.

County	No. of Beef Cows	No. of Milk Cows	No. of Hogs and Pigs	No. of Sheep and Lambs
Juab County	(D)	(D)	100	12,500
Millard County	19,563	11,177	1,189	10,458
Sanpete County	19,800	6,507	503	67,526
Sevier County	12,266	4969	638	53

(D) ? Data withheld by the U.S. Department of Agriculture to avoid disclosing information on individual landowners.

Table 3-3. Results of AFO/CAFO inventory for the middle Sevier River (HUC 16030003).

Operation Type and Size	Total Number	Distance to Nearest Waterway						
		Unknown	< 100 Feet	100 to 500 Feet	500 to 1000 Feet	1000 to 2000 Feet	2000 to 5000 Feet	> 5000 Feet
AFO < 300 Animal Units	46	1	10	5	1	7	7	15
AFO 300 to 1000 Animal Units	16		2	1	1	1	2	9
CAFO > 1000 Animal Units	6			3		2		1
Neither AFO or CAFO < 300 Animal Units	6		3			1	1	1
Neither AFO or CAFO 300 to 1000 Animal Units	1		1					
Potential CAFO < 300 Animal Units	6		6					
Potential CAFO 300 to 1000 Animal Units	5		4	1				

Table 3-4. Results of AFO/CAFO inventory for the lower Sevier River (HUC 16030005).

Operation Type and Size	Total Number	Distance to Nearest Waterway						
		Unknown	< 100 Feet	100 to 500 Feet	500 to 1000 Feet	1000 to 2000 Feet	2000 to 5000 Feet	> 5000 Feet
AFO < 300 Animal Units	106	25	15	12	5	6	9	34
AFO < 1000 Animal Units	1		1					
AFO 300 to 1000 Animal Units	23	4	7	1	1	4		6
CAFO > 1000 Animal Units	16	1	6	1	1	1	3	3
Neither AFO or CAFO < 300 Animal Units	4	1	2				1	
Potential CAFO < 300 Animal Units	16		11	4			1	
Potential CAFO 300 to 1000 Animal Units	2	1	1					

Table 3-5. Livestock information by reach supplied by local landowners and NRCS officials.

Location	Number of Animal Units
Between Clear Creek and Annabella Diversion	300
Between Annabella Diversion and Rocky Ford Reservoir	4000
Rocky Ford Reservoir to Yuba Dam	4,500
Yuba to Leamington	2000

3.3 Irrigation

The Sevier River and other major tributaries are diverted several times throughout the course of the lower watershed. In fact, the Sevier River is perhaps the most intensively used river within the state of Utah.

Side roll irrigation near Salina.

Figure 3-3 shows the extent of canals and other irrigation pathways within the watershed. The diverted water is generally used for stock watering and irrigation. Irrigation return flows are potential pollutant sources because they can acquire nutrients and salinity from fields. Flood irrigation in particular is potentially a major source because of the large amounts of water used in the process.

During the field assessment, it was noted that almost all of the fields in the Sevier River valley were irrigated by some method. Most fields were irrigated with flood irrigation through the use of canals and return flows were mostly through subsurface flow; few surface returns were observed. Other types of irrigation in the watershed included center pivot and side-roll irrigation.

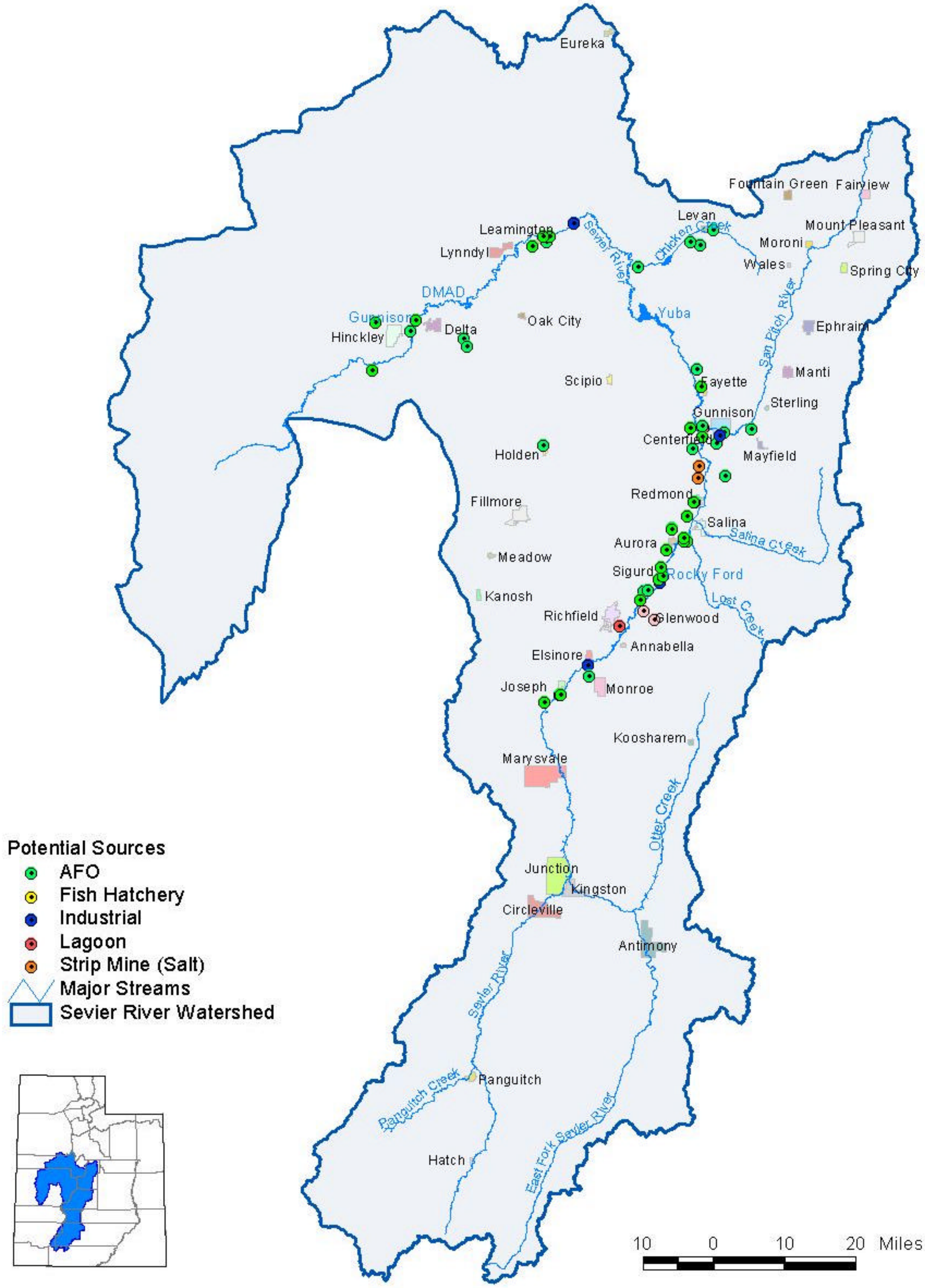

Figure 3-2. Potential sources of impairment identified during the field assessment.

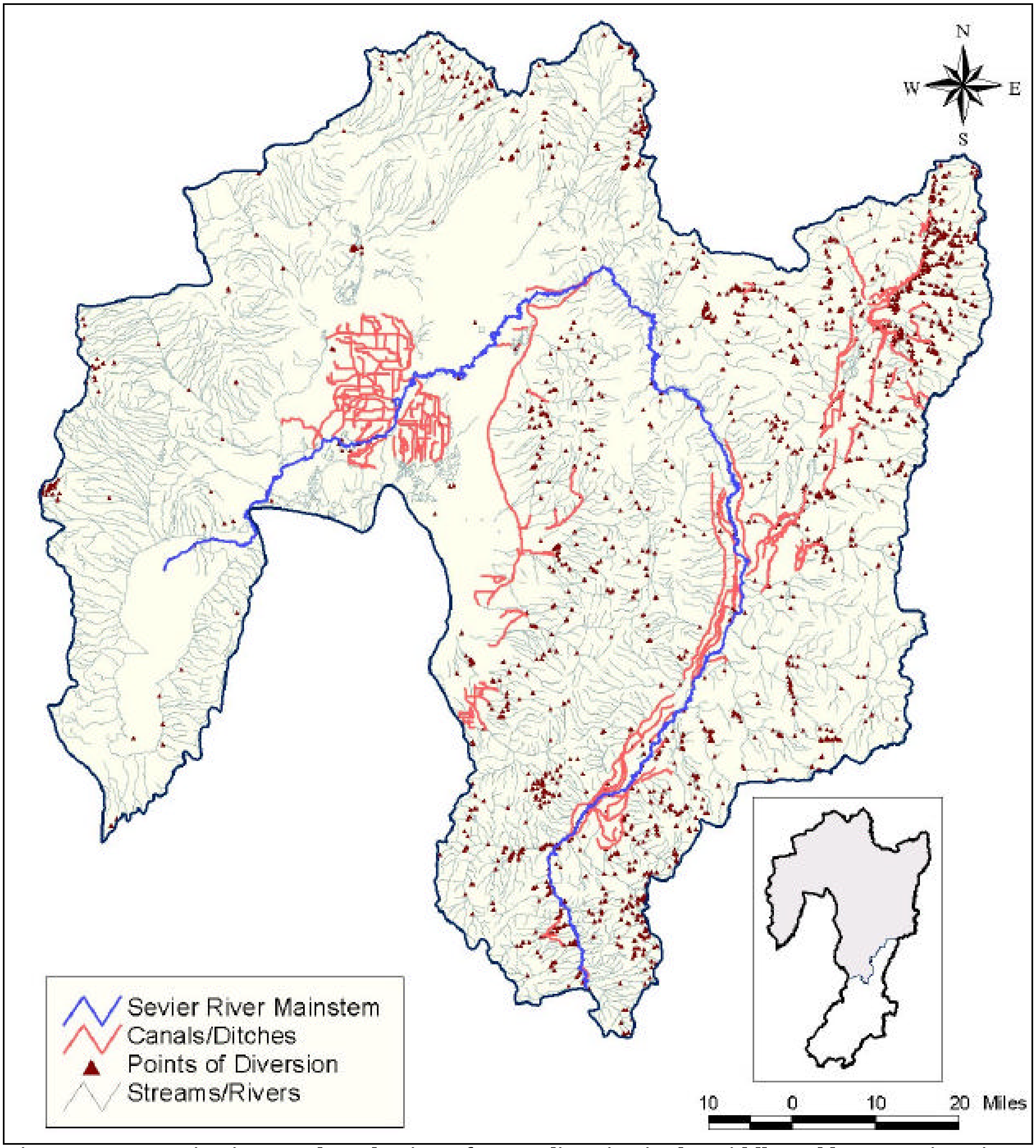

Figure 3-3. Irrigation canals and points of water diversion in the middle and lower Sevier River watershed.

3.4 Streambank Erosion

A streambank erosion assessment was performed throughout the lower Sevier River watershed by documenting the extent of streambank erosion and entrenchment. Streambank erosion is a potential source of sediment to streams in the watershed. The different types of streambank erosion observed in the watershed are identified below.

- Entrenchment
- General disturbance (i.e., cattle grazing on streambanks)
- Channelization
- Flow alterations (i.e., below the dams)

The Sevier River is a highly sinuous, meandering channel. The bankfull stream channel is approximately 50 to 60 feet wide and the banks typically range from 4 to 8 feet in height but can be much higher. The bank soil is composed of silty clay loam, is slightly saline, strongly alkaline and calcareous. Given these characteristics the banks have little inherent strength to counter lateral erosion. Virtually all banks located along the outside of meanders are vertical cutbanks, devoid of vegetation, and actively eroding.

The Sevier River from the Annabella Diversion to the confluence with Salina Creek generally had low to moderate entrenchment. Stable vegetated banks and good channel substrate were observed at multiple locations along this reach, and the Rocky Ford Reservoir did not appear to be adversely affecting the downstream channel conditions. Cattle grazing along streambanks was observed and is a potential source of streambank instability and erosion.

From Salina Creek to the Yuba Dam, the Sevier River had moderate to high levels of entrenchment. Streambanks had poor vegetation and streambank erosion is potentially a large source of sediment in this segment. Causes of the erosion are most likely flow modifications and highly erodible soils.

Streambanks were severely affected by flow modifications immediately below the Yuba Dam. Severe erosion and poor vegetation was observed. The Sevier River downstream of the dam also appeared murkier than upstream segments and poor channel substrate was present (e.g., silty, embedded stream channels). However, improved streambanks and vegetative cover were observed downstream in the river from Leamington to the DMAD Reservoir. Moderate entrenchment was observed throughout the Sevier River from the Yuba Dam to the DMAD Reservoir. The DMAD Reservoir is a potential source of sediment because of shoreline erosion and sediment re-suspension caused by fluctuating water levels. Similar conditions were observed in the Sevier River from the DMAD Reservoir to the Gunnison Reservoir.

In general, streambank erosion is a large potential source of sediment for the Sevier River from the confluence with Salina Creek to the Gunnison Bend Reservoir. The segments from the confluence with Salina Creek to the Yuba Reservoir, and directly downstream of the Yuba Reservoir appeared to have the worst levels of entrenchment and streambank instability. Streambank erosion may also be contributing to poor stream habitat and embeddedness observed in the Sevier River near Lynndyl. Streambanks and riparian habitat were generally good in the upland areas of several major tributaries.


Gully erosion in a Sevier River tributary


Sevier River near Richfield, Utah


Sevier River near Lynndyl, Utah


Sevier River downstream of Yuba Dam


Stream disturbance in Lost Creek


Shoreline erosion in DMAD Reservoir

3.5 Wastewater Disposal

Three major wastewater disposal lagoons were identified during the field assessment – the Salina Lagoons, Richfield Lagoons, and the Gunnison Lagoons. The exact location of the lagoons is shown in Figure 3-2. Drainage seeps were found near the Salina Lagoons and the Gunnison Lagoons are located directly adjacent to a dry reach of the San Pitch River. All three lagoon systems are potential sources for nutrients in the Sevier River. Most of the households in smaller towns and rural areas in the Sevier River watershed are connected to septic systems.

Gunnison lagoons.

It should be noted that the Salina lagoons historically discharged to the Sevier River until the late 1980s and have the infrastructure necessary to do so in the future. Discharge monitoring data are available for the period February 1978 to March 1987 and indicate that average daily flows were approximately 0.6 million gallons per day (mgd) with a TP concentration of 8.3 mg/L. The 0.6 mgd is approximately the design capacity of the lagoons (Utah Board of Water Resources, 1999). The estimated annual TP loads during this time period were almost 7,000 kg/yr. Based on the average annual flow in the Sevier River in this segment the Salina lagoons were solely responsible for increasing TP concentrations by almost 0.03 mg/L, or 60 percent of the TMDL target. Due to these considerations a recommendation of this TMDL is that if and when the Salina lagoons exceed their design capacity they will be considered a significant source of phosphorus based on historical discharge data. As such it will be necessary to develop permit limits in conjunction with the limits of the TMDL. It is evident that to comply with the 0.05 mg/L target value may require the design and development of treatment options to reduce TP concentrations well below the best available technology (BAT) capabilities of the current lagoon system.

3.6 Miscellaneous Sources

Miscellaneous other sources of impairment were identified throughout the watershed. Tamarisk (salt cedar) trees are an indirect source of impairment because of the relatively large quantities of water they consume. This can lead to reduced flows and higher salinity concentrations throughout the watershed. Dense populations of tamarisk trees were observed primarily in the Sevier River Valley from the confluence of the San Pitch River to Sevier Lake.

Tamarisk along the Sevier River near Lynndyl.

Two fish hatcheries were identified near two different tributaries to the Sevier River east of Richfield. These are the Glenwood Fish Hatchery (National Permit Discharge Elimination System (NPDES) number UTG130005) and the Trophy Fish Hatchery

(NPDES number UTG130002). Clean mountain water from the upland areas are captured and used for the trout fisheries and both are potential sources of nutrients. However, the tributaries to which these hatcheries discharge are used for irrigation downstream which reduces the likelihood that the nutrients are available for the listed reaches of the Sevier River.

There are four major reservoirs on the main stem of the Sevier River from the Annabella Diversion to the Sevier Lake. Evaporation from these reservoirs is a potential source of salinity because salts are concentrated in the reservoirs when water evaporates. This phenomenon is more significant in the wide, shallow reservoirs such as the upstream portion of the Yuba Reservoir and the Rocky Ford Reservoir. The Chicken Creek Reservoir is also very wide and shallow. It was estimated in the field that the Chicken Creek Reservoir contributes more salt to Chicken Creek than other potential upstream sources.

A fish hatchery near the Sevier River.

Salt and soil disturbance from the Redmond salt mine and other gravel mines in the watershed are a potential source of salinity and sediment. Also, roads are salted in the winter and can contribute significant amounts of salt runoff.

4.0 TECHNICAL ANALYSIS

This section discusses the approach that was used to estimate loading capacities and existing pollutant loadings for the ten listed stream segments within the Sevier River watershed. It also presents the methodology that was used to estimate the loadings from each source category.

4.1 Derivation of Loading Capacity and Existing Loads

The loading capacity is defined as the amount of a pollutant that can be assimilated by the waterbody while still attaining and maintaining water quality standards. There are several options for estimating existing and allowable loadings including using watershed models and statistical approaches based on existing water quality data.

A watershed model is essentially a series of algorithms applied to watershed characteristics and meteorological data to simulate naturally occurring land-based processes over an extended period of time, including hydrology and pollutant transport. Many watershed models are also capable of simulating in-stream processes using the land-based calculations as input. Once a model has been adequately set up and calibrated for a watershed it can be used to quantify the existing loading of pollutants from subwatersheds or from land use categories. Models can also be used to assess the potential benefits of various restoration scenarios (e.g., implementation of certain best management practices).

Two significant challenges were associated with setting up and calibrating a watershed model for the Sevier River watershed. First among these is the vast number of diversions, canals, and other irrigation pathways that have altered the natural flow of the river (see Figure 3-3). Existing models have limited ability to simulate such a system. Another challenge was posed by the significant impact that snowmelt has on runoff and streamflow for certain parts of the watershed for certain periods of the year and the limited data on the timing and nature of the snowmelt. An initial attempt at applying the Soil Water Assessment Tool (SWAT) to the Lost Creek subwatershed indicated that these two challenges made a suitable hydrologic calibration difficult to obtain.

A statistical approach was therefore used to develop the loading capacities and existing loadings within the watershed. The advantages to using a statistical approach are that it accurately identifies the allowable and existing loads, allows one to use data for all flow and loading conditions, and provides insight into the critical conditions. The disadvantages to using a statistical approach are that is provides limited information regarding the relative sources of the loads and does not allow one to simulate the impact of best management practices.

The following steps were taken to implement the statistical approach for the Sevier River TMDLs:

1. A flow duration curve for each segment was developed using the available flow data. This was done by generating a flow frequency table that consisted of ranking all of the observed flows from the least observed flow to the greatest observed flow and plotting those points.
2. The flow curve was translated into a load duration (or TMDL) curve by multiplying each flow by the water quality standard and a conversion factor and plotting the resulting points.
3. Each water quality sample was converted to a daily load by multiplying the sample concentration by the corresponding average daily flow on the day the sample was taken. The load was then plotted on the TMDL graph.
4. Points plotting above the curve represent deviations from the water quality standard and unallowable loads. Those plotting below the curve represent compliance with standards and represent allowable daily loads.

5. The area beneath the TMDL curve is the loading capacity of the stream. The difference between this area and the area representing current loading conditions is the load that must be reduced to meet water quality standards.

Although the load duration approach does not directly provide information on the source of pollutant loads, it can help to identify the issues surrounding the impairment and roughly differentiate between types of sources (Figure 4-1). Loads that plot above the curve in the 1 percent to 15 percent flow ranges (low flow conditions) are likely indicative of constant discharge sources. Those plotting above the curve between 30 percent and 90 percent likely reflect precipitation driven contributions. Some combination of the two source categories lies in the transition zone of 15 to 30 percent. Those plotting above the curve in the less than 1 percent and greater than 90 percent flow ranges reflect extreme hydrologic conditions of drought or flood, respectively.

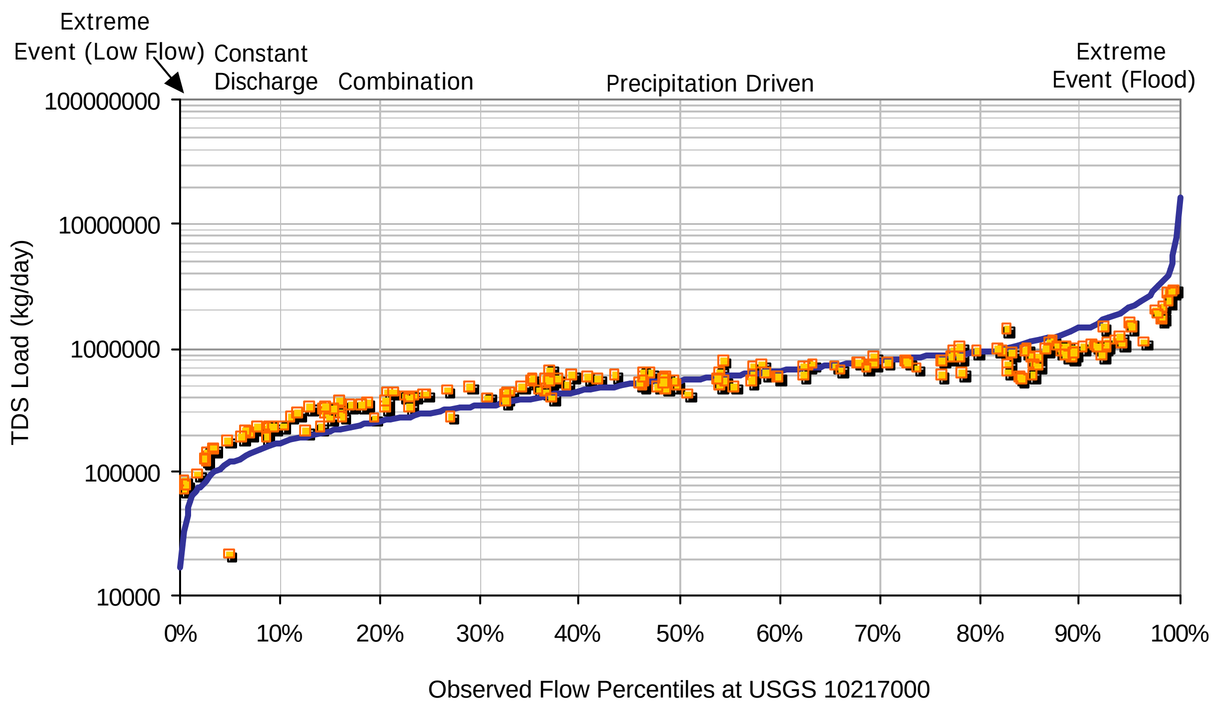

Figure 4-1. Illustration of source information provided by a load duration curve. Data are for the Sevier River above Yuba Reservoir southwest of Fayette.

Table 4-1 identifies the listed stream segments along with the DWQ water quality monitoring sites and the accompanying USGS gage used to develop a load-duration curve for each stream segment. In some cases long-term flow data were not available and instantaneous flow data from the DWQ sampling had to be used. The DWQ and USGS monitoring sites are shown in Figure 4-2.

Table 4-1. Water Quality and Stream Flow Stations used in the Load Duration Curve Development.

Stream Segment	DWQ Ambient Water Quality Station (Period of Record)	USGS Stream Flow Station (Period of Record)
Yuba Dam to the confluence with Salina Creek	494247 (12/14/74 to 8/1/02)	10217000 (10/1/17 to 9/30/02)
U-132 Crossing to Yuba Dam	494215 (11/17/77 to 4/30/02)	None – DWQ Data Used
DMAD Reservoir to U-132 Crossing	494210 (9/9/76 to 7/30/02)	10224000 (4/25/14 to 9/30/02)
Gunnison Bend Reservoir to DMAD Reservoir	494128 (8/10/76 to 6/11/02)	None – DWQ Data Used
Crear Lake to Gunnison Bend Reservoir	494110 (5/19/80 to 6/11/02)	None – DWQ Data Used
Salina Creek	494730 (7/16/75 to 6/20/02)	10206000 (4/25/14 to 9/30/95)
Lost Creek	494512 (5/23/78 to 6/20/02)	None – DWQ Data Used
Peterson Creek	494752	None – DWQ Data Used

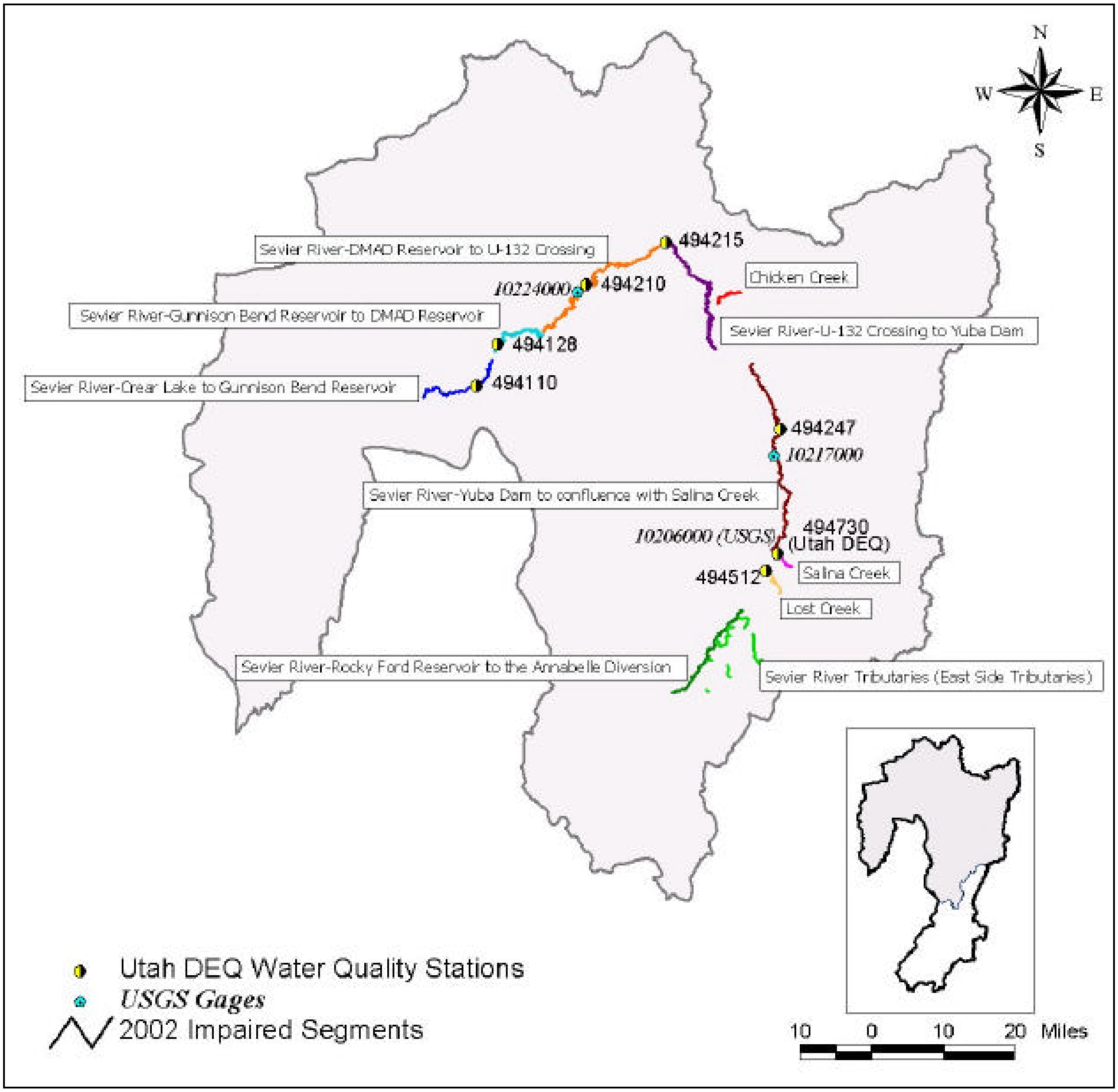

Figure 4-2. Utah DWQ water quality monitoring sites and USGS stream flow gage sites.

4.2 Estimating Loads from Each Source Category

Once existing and allowable loads were calculated for each stream segment, separate analyses were performed to estimate the magnitude of the existing loadings from each significant source category. Information on the sources of existing loadings is critical to identifying and implementing successful management measures, or deciding that the cause of the impairment is primarily due to natural sources.

Several methods were used to estimate the loads from each source category and are explained below. Relatively good information existed to estimate loads from some sources for some pollutants. In other cases the available information had to be used in combination with best professional judgment and the results of the field reconnaissance to arrive at a load estimate. In these situations a variety of information was used to assess the relative magnitude of the source categories. For example, some sources are associated with certain flow regimes and the results of water quality sampling can indicate dominant sources.

4.2.1 Irrigation Return Flows

The Sevier River is perhaps the most intensively used river in the state of Utah. Diverted water is generally used for stock watering and irrigation and irrigation practices in the watershed are a potential source of TDS and TP. Irrigation water can acquire nutrients and salinity from fields and return it to the river through surface or subsurface flows. Flood irrigation in particular is potentially a major source of salinity and nutrients because of the large amounts of water used in the process.

To assess the contribution of TDS and TP from irrigation in a listed segment the number of acres of irrigated land in that segment was multiplied by the volume of water applied per year, the average irrigation efficiency in that segment of the river, a factor representing the portion of unconsumed irrigation water returning to the stream segment, and a value representing the increase in concentration of TDS or TP associated with returned irrigation water.

The volume of water applied per year was assumed to be 36 inches based on recommended consumptive use guidelines published by the Utah State University Extension (Hill and Koenig, 1999). The consumptive use guidelines vary by region and crop, but 36 inches was chosen as a representative value. Personal communication with several landowners and irrigation companies also indicated this was a representative value.

Average efficiencies for each area of the watershed were chosen based on personal communication with landowners and irrigation companies. There appeared to be consensus that efficiencies are highest at the most downstream section of the watershed (75 to 85 percent) and decline moving upstream toward Richfield (40 to 50 percent).

An intensive study of the Sevier River watershed (UDNR, 1995) reported that approximately 50 percent of unconsumed irrigation water returns to the Sevier River. This value was therefore used in the calculation of TDS loads from irrigation return flows.

Very little information exists regarding the concentration of TDS in irrigation return flows. A literature search was conducted and resulted in only a few studies directly addressing this topic. One (USDI, 2001) reported that 3.65 tons of TDS loading is attributable to each acre-foot of irrigation return flow. This equates to a concentration of approximately 2,700 mg/L. However, this value includes the salinity that existed in the irrigation water prior to when it was applied and is also not site-specific to the Sevier River watershed. An increase of 1,000 mg/L TDS associated with irrigation return flows was therefore chosen for the Sevier River TMDLs based on available water quality sampling data in the watershed above and below irrigated lands.

Little information exists regarding the concentration of TP in irrigation return flows. However, two studies (Barry, 1996 and Little et al., 2003) reported increased concentrations of approximately 0.05 mg/L TP due to irrigation return flows. This value was therefore chosen for the Sevier River TMDLs.

4.2.2 Livestock

As discussed in Section 3 numerous animal feeding operations are located in the Sevier River watershed. More than 200 were documented during the Farm Bureau's survey. Poor management practices, including feedlot runoff, overgrazing, poor manure management, and grazing in and around streams were observed at several feeding operations during the TMDL field assessment. These practices represent a potentially significant pollutant source, especially for TP.

To assess the contributions from these operations on water quality, estimates were made of the number of livestock in each segment of the river. These were based primarily on the information supplied by the Utah Farm Bureau and complemented by the latest U.S. Department of Agriculture Census data, the results of the field assessment, and personal communications with landowners and NRCS personnel. Only facilities within 500 feet of a waterway were assumed to be potential contributors of pollutants. The number of each type of animal was multiplied by the TP concentration in its manure (expressed on a per kg basis) (NRCS, 1999), a representative animal weight, and a 5 percent factor to account for the portion of the manure that is available to runoff the feeding operation to the stream (Koelsch and Shapiro, 1997).

4.2.3 Septic systems

Many of the residents in the Sevier River valley use septic systems to treat their domestic wastewater. Septic systems that are properly designed and maintained should not serve as a source of contamination to surface waters. However, septic systems do fail for a variety of reasons. When these septic systems fail hydraulically (surface breakouts) or hydrogeologically (inadequate soil filtration) there can be adverse effects to down gradient surface waters.

Site-specific information on the location of failing septic systems is not currently available for the Sevier River watershed. Therefore estimates of the loads of TP from these sources were based on the following sources of data and assumptions:

- The total number of septic systems in each county was derived from the 1990 and 2000 U.S. Census.
- The proportion of septic systems in the Sevier River valley was estimated based on a GIS analysis.
- The population served by each septic system was assumed to be 2.5 persons per household, based on the 2000 U.S. Census.
- A literature value (265 liters/person/day) was used for the average per capita daily discharge (Horsley and Witten, 1996)
- A literature value of 5 mg/L was used for the TP concentration of septic effluent (USEPA, 2002)
- Best professional judgment was used to estimate septic failure rate at 15 percent.

4.2.4 Land Erosion

Land erosion in the Sevier River watershed was estimated using the Universal Soil Loss Equation (USLE). The USLE (Wischmeier and Smith, 1978) is the most common and best known method to estimate gross annual soil loss from upland erosion. The USLE is an index method having factors that represent how climate, soil, topography, and land use affect soil erosion caused by raindrop impact and surface runoff. Rather than explicitly representing the fundamental processes of detachment, deposition, and transport by rainfall and runoff, the USLE represents the effects of these processes on soil loss. These influences are described in the USLE with the equation:

$$A = (R)\,(K)\,(LS)\,(C)\,(P)$$

where, A is estimated soil loss in tons/hectare for a given storm or period; R is a rainfall energy factor; K is a soil erodibility factor; LS is a slope-length, slope steepness factor; C is vegetative cover factor; and P is a conservation practice factor.

The individual USLE factors for the Sevier River watershed were estimated based on available GIS data and literature values. GIS data layers for elevation, soils, and land cover helped to facilitate the USLE analysis for a large, watershed scale area such as the entire Sevier River watershed. Data available for such an analysis included the State Soil Geographic Database and GIS coverage for Utah (STATSGO), the Gap Analysis Program's land cover data for Utah, and the U.S. Geological Survey's 30-meter Digital Elevation Models (DEMs) for the Sevier River watershed. Also, the Surface Geology GIS coverage for Utah was used to better define badland areas that might inherently have more soil erosion. The geology, soils, and land cover GIS coverages were merged to create a new polygon coverage, where each polygon had a unique combination of land cover, soils, and geology information. The polygon data were then input into a database to calculate a sediment load per polygon. Average slopes were calculated from the DEM data for each land use, and were also input into the database. Slope lengths were estimated from the DEM data. A description of each of the USLE parameters, and the origin of the data are described below.

- Rainfall and Runoff (R) – Estimated for the entire region based on literature values (Haan, Barfield, and Hayes, 1994)
- Soil Erodibility (K) – Calculated from the STATSGO data. Average weighted K-factors were calculated using the K-factor for the surface layer of each soil, and the soil's percent composition in the larger map unit.
- Slope and Slope Length (S)(L) – Average slopes and slope lengths were calculated for each land use using the 30-meter DEM data. Slope and slope lengths were input into defined formulas to calculate a slope factor (S) and slope length factor (L).

Equation	Conditions
S = 10.8sin ? + 0.03	sin ? < 0.09
S = 16.8sin ? - 0.50	sin ? = 0.09

Note: ? is the slope angle

$$L ? \left(\frac{?}{72.6} \right)^{m}$$

Where ? = slope length, and m = the slope length exponent derived from literature values, and based on the percent slope and the estimated rill to interrill erosion.

- Cover and Management (C) – Literature values based on the GAP land cover classes (Haan, Barfield, and Hayes, 1994)
- Erosion Control Practice (P) – Estimated from literature values (Haan, Barfield, and Hayes, 1994), (Brady, 1990)

The six USLE soil factors were multiplied together for each unique polygon in the Sevier River. Annual loads and annual loads per acre were then calculated for each polygon. The results of the USLE analyses for the entire watershed are shown in Figure 4-3.

Several steps had to be taken to process the results of the USLE analysis to determine a TSS load to the Sevier River. First, the USLE only predicts the erosion of sediment particles, and does not predict the transport of the sediment to and within stream reaches. Sediment yield to the river was therefore extrapolated from the USLE soil erosion estimates using literature values based on watershed size (Vanoni, 1975). Furthermore, the sediment yield to each specific reach was not calculated using the entire watershed area (e.g., from the monitoring station to the headwaters of the Sevier River). Rather, watershed areas were defined by the segment of interest upstream to the nearest dam or major diversion.

This resulted in an estimate of the sediment load within each reach primarily associated with local tributaries, and partially accounted for the fact that some sediment that is eroded never reaches the Sevier River due to the effect of diversions. The USLE and sediment yield analysis also results in an estimate of total sediment load, whereas observed in-stream loads are based on total suspended solids (TSS). TSS samples often underestimate the mass of sand-sized particles in a sample (Gray et al., 2000). For example, limited paired sampling of the Sevier River indicated that TSS samples could underestimate totals solids by as much as 20 to 50 percent. A 65 percent correction factor was therefore applied to estimate the portion of totals solids (from the USLE) that are measured by TSS.

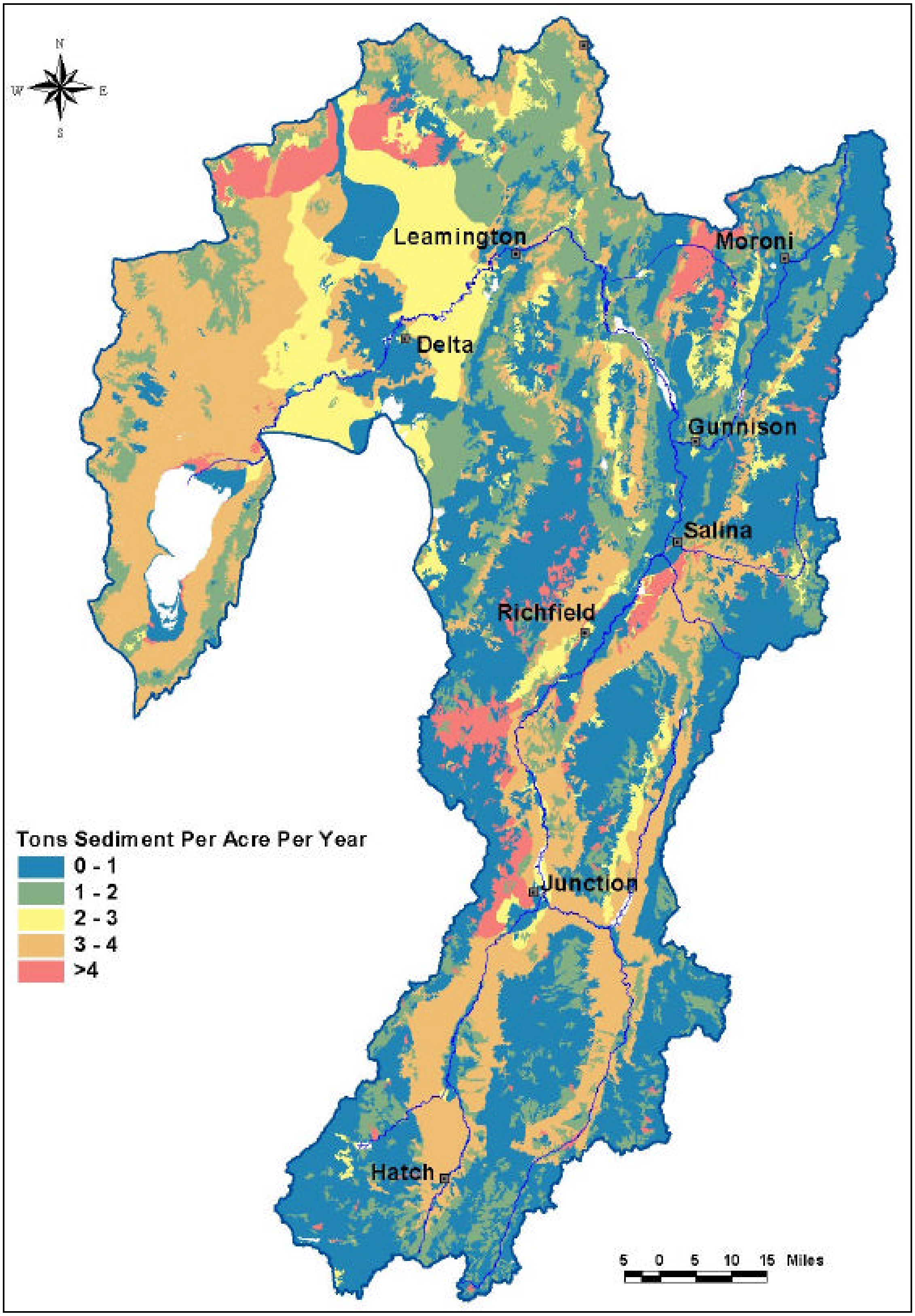

Figure 4-3. Predicted land erosion in the Sevier River watershed.

4.2.5 Streambank Erosion

Significant quantities of sediment can be mobilized from the bed and banks of active alluvial channels. Metrics of channel stability and bank erosion integrate longer-term channel process and fluvial function, and can provide a useful measure of siltation. Because bank erosion is spatially variable on a large scale within a watershed, it is very difficult to apply one approach to provide representative data on status and trends in channel health. Existing watershed models have limited ability to predict streambank erosion, and their usefulness in the Sevier River watershed is compounded by the high number of diversions. TSS and TP loads from streambank erosion were therefore estimated according to the results of the field assessment, corresponding literature values for bank erosion rates (Rosgen, 1996), and soils data from the NRCS. A sample calculation is provided below.

The results of the field assessment for Salina Creek to the Yuba Dam indicated moderate to high levels of near bank stress, high streambank erodibility, and average bank heights of approximately six feet. Literature values for these characteristics estimate the bank erosion rate at approximately 0.25 feet/year. The bulk density of the soil (from the NRCS soils database) is approximately 1.15 g/cm^3. Applying these values results in approximately 260,000 kg/yr/mile TSS of streambank erosion.

$$\frac{0.25\,\text{ft}}{\text{yr}} ? \frac{5{,}280\,\text{ft}}{\text{mi}} ? \frac{6\,\text{ft}}{\text{bank height}} ? \frac{1.15\,\text{g}}{\text{cm}^3} ? \frac{1\,\text{kg}}{1000\,\text{g}} ? \frac{28316.9\,\text{cm}^3}{\text{ft}^3} ? 257{,}910\frac{\text{kg}}{\text{yr}}$$

The results of this approach were then compared to available water quality data regarding streambank erosion. For example, Figure 4-4 displays the long-term average TSS concentration at various reaches along the Sevier River. The width of the plot is proportional to the TSS concentration at each sampling site. Potentially erosive reaches between successive sampling sites not impacted by significant tributary inflows or dams are indicated by an increase in the width of the plot, and potentially depositional reaches are indicated by a decrease in the width of the plot. TSS plots such as that shown in Figure 4-4 are even more informative when they display synoptic data (i.e., data collected at multiple stations on the same day under similar flow conditions). Unfortunately, the period of record at the various stations on the Sevier River is quite varied. There is only day, November 4, 1981, where TSS data were collected at more than seven of the stations. The results are plotted in Figure 4-5 and are fairly similar to the results in Figure 4-4.

Several observations can be made from Figures 4-4 and 4-5:

?? Long-term average TSS concentrations are relatively low below Rocky Ford Reservoir
?? Lost Creek potentially contributes a significant load of TSS to the Sevier River as displayed by the abrupt increase in concentrations. Note, however, that the data for immediately below Lost Creek are based on limiting sampling done in 1978 and 1980. No recent data are available.
?? The Sevier River is a potentially depositional reach between Lost Creek and the San Pitch River.
?? Yuba Dam traps a significant load of TSS.
?? The Sevier River is a potentially erosional reach between the outlet of Yuba Dam and DMAD Reservoir.

These observations will be further discussed in Section 5.

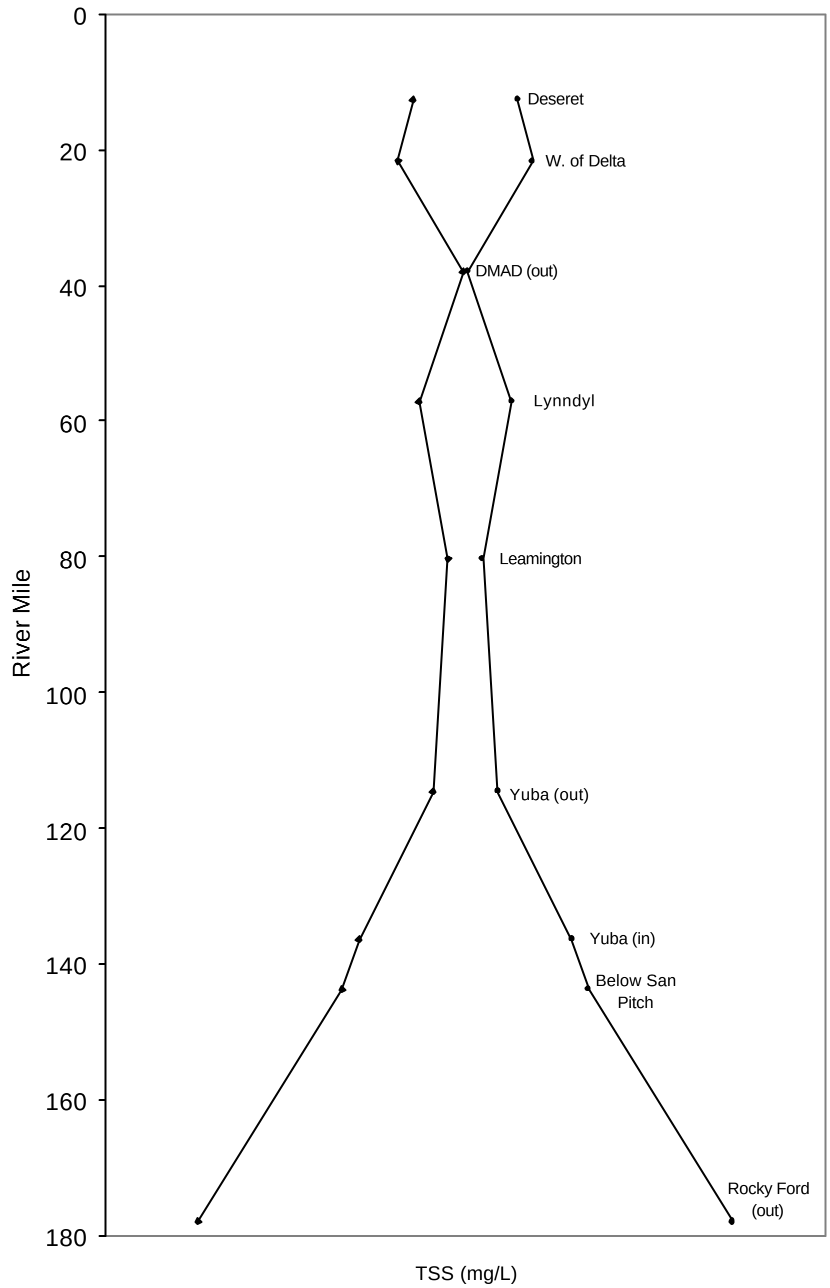

Figure 4-4. Average total suspended solids concentrations in the Sevier River downstream of Rocky Ford Reservoir. Width of plot indicates TSS concentration with one inch equal to approximately 85 mg/L TSS. Data shown are for the entire period of record at all stations.

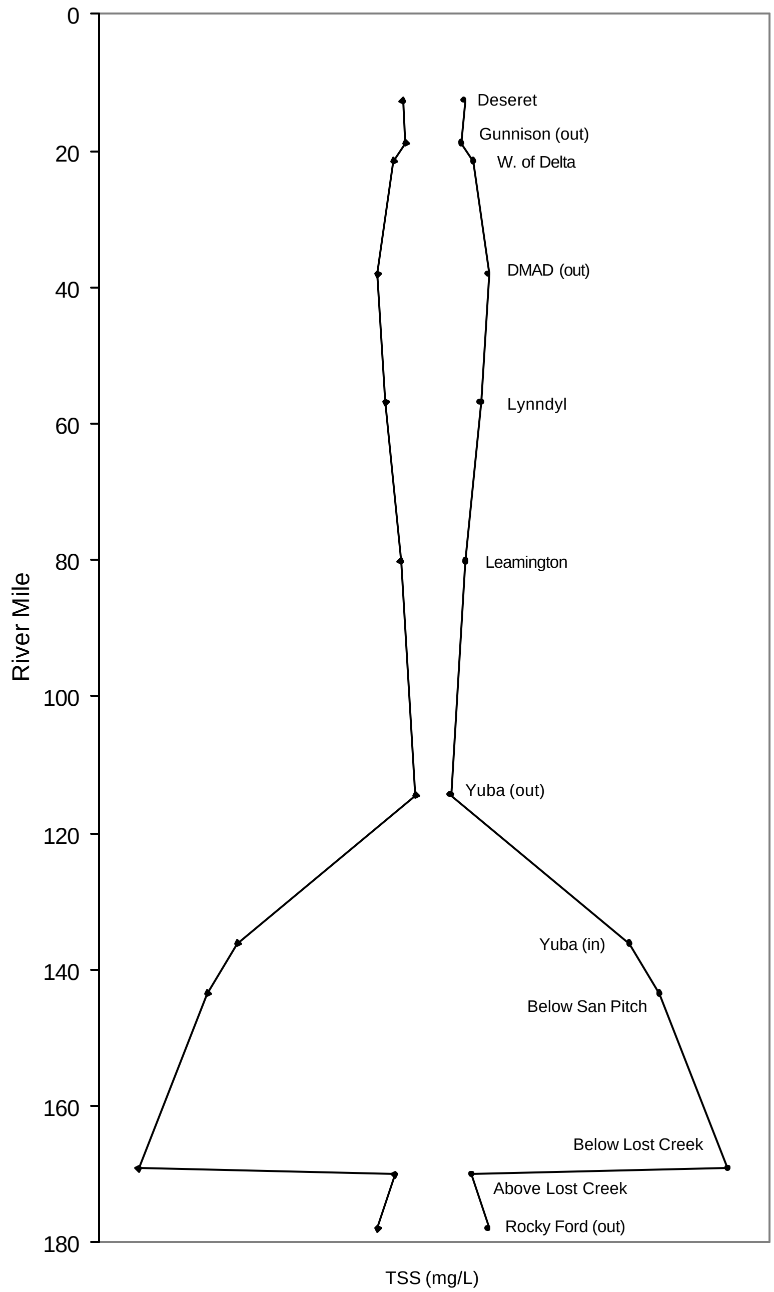

Figure 4-5. Total suspended solids concentrations in the Sevier River downstream of Rocky Ford Reservoir on November 4, 1981. Width of plot indicates TSS concentration with one inch equal to approximately 85 mg/L TSS.

4.2.6 Lagoons

The Richfield and Salina lagoons are both total containment lagoons which means that they do not discharge directly to any surface waters. However, the lagoons are designed to have some seepage and drainage seeps were observed near the Salina Lagoons during the field assessment.

A study of the Richfield lagoons was conducted in the late 1980s to determine their volume of seepage (personal communications with Roger Foyse, City of Richfield, May 20, 2003). The results indicated that 0.25 inches per day of effluent seeped from the lagoons and could therefore be a source of pollutants to the Sevier River. This is the maximum volume of seepage allowed by state regulations and it was assumed that a similar rate applies to the Salina lagoons. The 0.25 inches were multiplied by the surface area of the lagoons and the average TDS concentration historically reported by each facility in the Permit Compliance Database (PCS). For estimates of TP loadings, a literature value of 4 mg/L (Litke, 1999) was used to derive loading estimates because no PCS data are available.

5.0 WATER QUALITY ASSESSMENT, TMDL ALLOCATIONS, AND IMPLEMENTATION RECOMMENDATIONS

This section provides an inventory and analysis of the available water quality (or other watershed monitoring) data to confirm the impairment and summarize existing water quality conditions. The locations, periods of record, and summary statistics for available flow and water quality data are presented. This section also presents the existing and allowable pollutant loads for each listed segment and estimates the contribution of the current loads associated with each major source category. The allowable loads are allocated among wasteload allocations (WLAs) for point sources, load allocations (LAs) for nonpoint sources and background sources, and a margin of safety to account for uncertainty in the analysis. Recommended best management practices are also presented for each segment.

5.1 Monitoring Data

Both USGS and DWQ monitor water quality in the Sevier River basin. DWQ data for 284 stations in the Sevier River basin were downloaded from USEPA's STORET database and provided by DWQ. Over 180,000 records and 211 parameters were available in the database ranging from 1974 to 2002. Water quality data from USGS ambient sampling and special studies in the Sevier River basin were downloaded from the online National Water Information System (NWIS) database. Eighty-nine stations with over 36,000 records were obtained. Summaries of the available data are provided in Appendix B.

DWQ has identified ten segments in the Sevier River basin that are impaired and listed on Utah's 2002 Section 303(d) list (Section 2.1). There are 59 DWQ and USGS stations on the impaired streams. Several different parameters were sampled at each station to evaluate the total dissolved solids (TDS), sediment, and phosphorus impairments. Table 5-1 shows the sampled parameters associated with each cause of impairment. The following sections summarize the available data for each listed segment, ordered from upstream to downstream.

Table 5-1. Causes of Impairment and Associated Sampled Parameters.

Cause of Impairment	Sampled Parameters
Phosphorus	Total Phosphorus (TP), Dissolved Phosphorus, Orthophosphate
Sediment	Total Suspended Solids (TSS), Turbidity (Turb)
Total Dissolved Solids	Dissolved Solids (TDS), Calcium, Carbonate, Chloride, Hardness, Magnesium, Potassium, Sodium, Specific Conductance, Sulfate

5.2 Sevier River from Rocky Ford Reservoir to the Annabella Diversion

The Sevier River from Rocky Ford Reservoir to the Annabella Diversion is listed for TDS. Recent TDS data are available at three stations and an analysis of the data shows that only 8 percent of the samples collected between 1996 and 2002 were above the 1,200 mg/L standard. The data therefore meet the full use support criteria for assessing agricultural beneficial use support. Furthermore, average monthly concentrations at station 494760 (located below Rocky Ford Reservoir and the station with the most data) are well below the standard (Figure 5-1). There also does not appear to be a long-term trend in TDS over the period of record (Figure 5-2). DWQ is therefore recommending that no TMDL is needed for this segment of the river and that it be de-listed based on the available data.

Table 5-2. Summary of TDS data for stations on the Sevier River from Rocky Ford Reservoir to the Annabella Diversion.

Station	No. of Samples	Average	Min	Max	CV*	Min Date	Max Date
494760 (below Rocky Ford Reservoir)	74	671	394	1,000	18%	2/16/77	6/3/97
494805 (U119 crossing east of Richfield)	29	632	262	1,964	66%	5/22/78	6/3/97
494820 (north of Annabella)	10	322	254	406	13%	5/22/78	4/6/94

*CV = coefficient of variation (standard deviation divided by the mean).

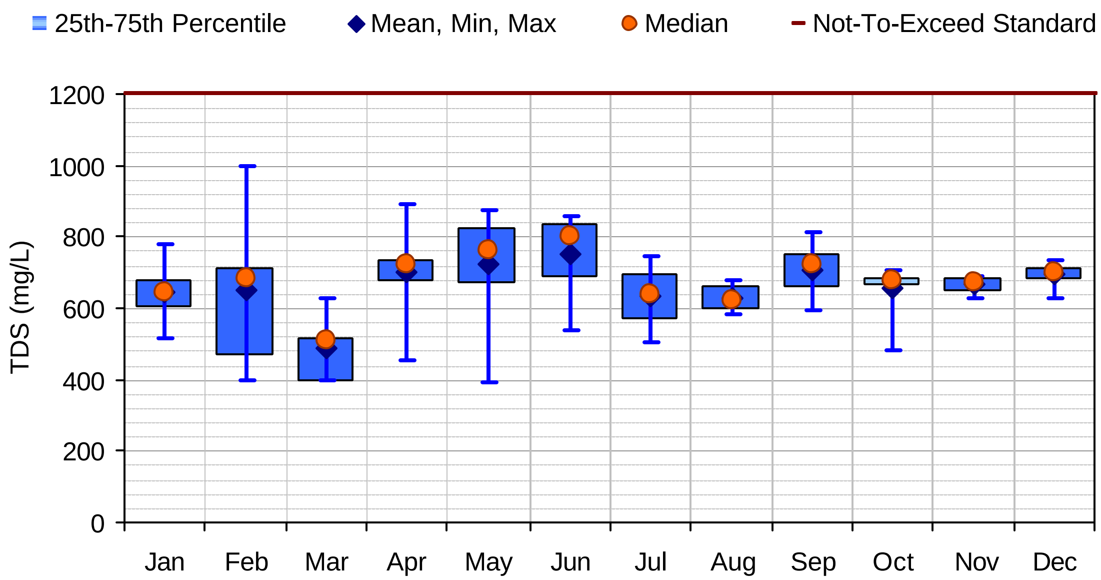

Figure 5-1. Monthly average TDS data at station 494760 (Sevier River below Rocky Ford Reservoir). Data cover the period February 16, 1977 to June 3, 1997.

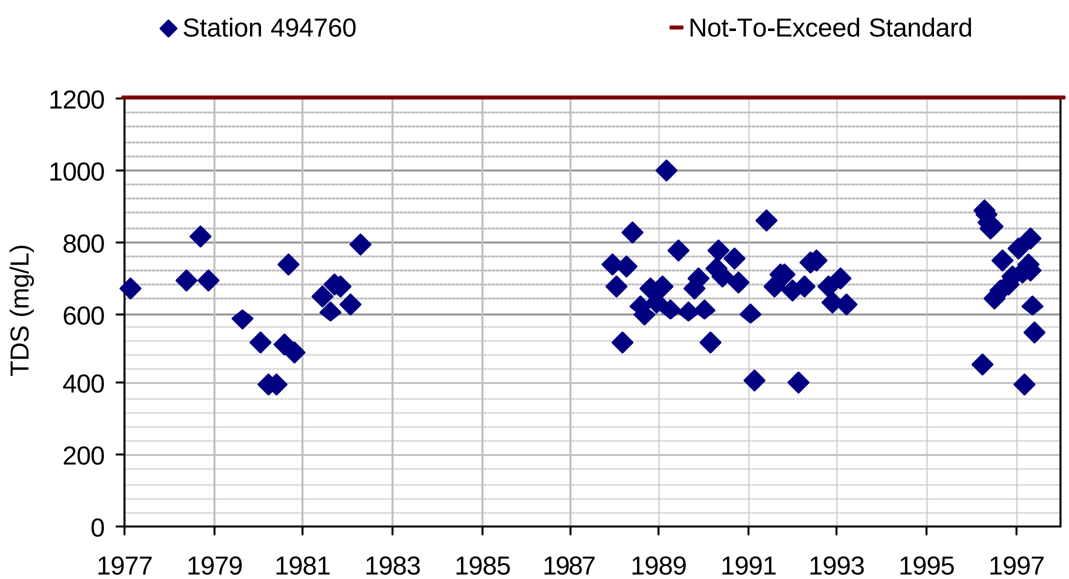

Figure 5-2. All TDS data at station 494760 (Sevier River below Rocky Ford Reservoir).

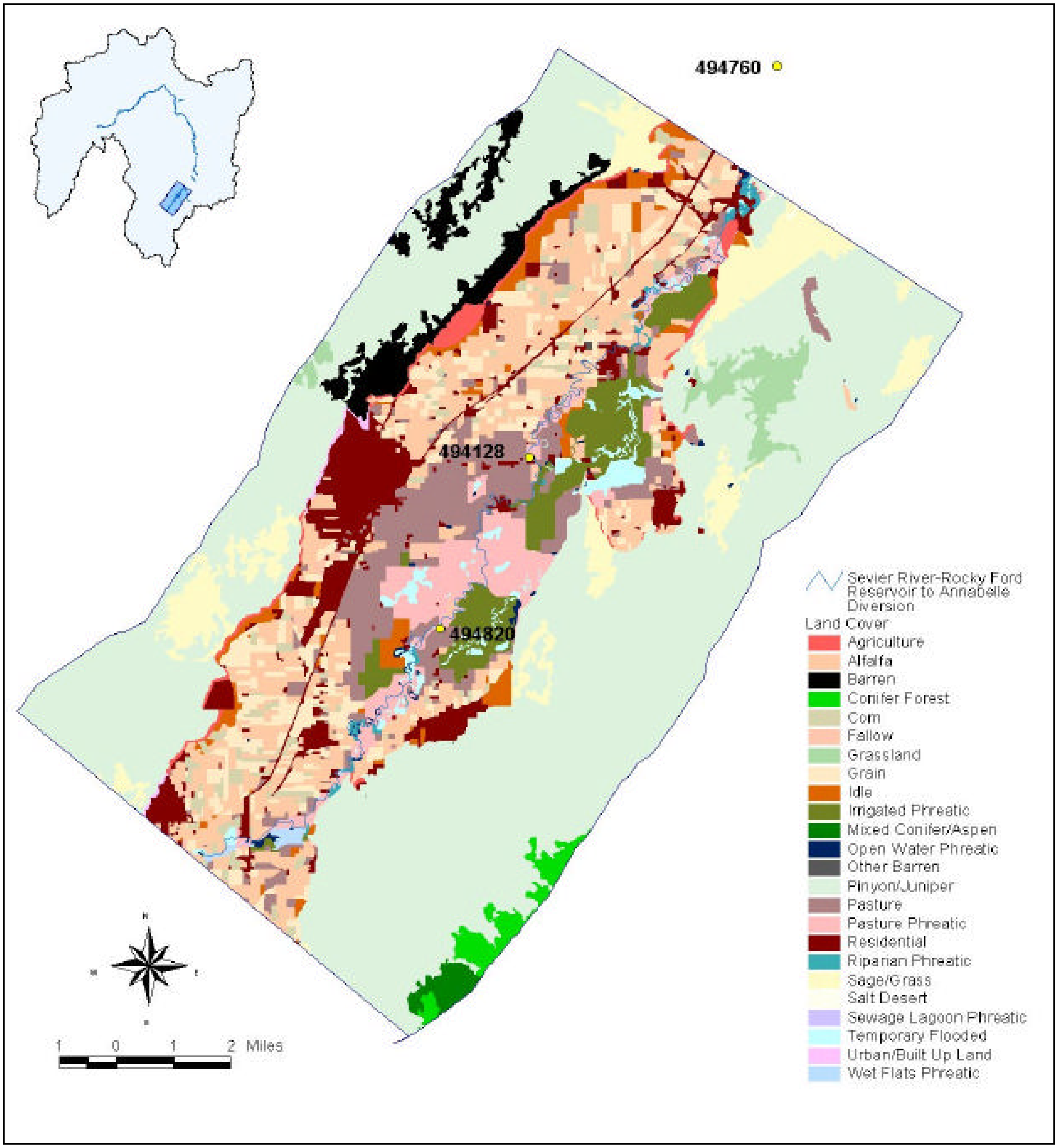

Figure 5-3. Land use and land cover within the buffered zone along the Sevier River – Rocky Ford Reservoir to Annabella Diversion.

5.3 Sevier River from the Yuba Dam to the confluence with Salina Creek

The Sevier River from Yuba Dam to the confluence with Salina Creek is listed for total dissolved solids, sediment, total phosphorus, and habitat alteration. Land use/land cover along the stream corridor is dominated by sage/grass (34 percent), pinyon/juniper (13 percent), and alfalfa (8 percent) (Figure 5-4).

The listing for habitat alterations is closely related to the sediment and total phosphorus listings because all three are associated with altered streamflows and significant streambank destabilization. Because it is not entirely appropriate to develop a TMDL for habitat, only sediment, phosphorus, and TDS TMDLs are presented in this document. However, many of the BMPs recommended to reduce loads of these pollutants are also expected to improve habitat conditions (e.g., remove tamarisk trees, improve streambank conditions). Numerous researchers have shown a direct link between poor habitat conditions and increased streambank erosion (e.g., Rosgen, 1996; Leopold et al., 1964).

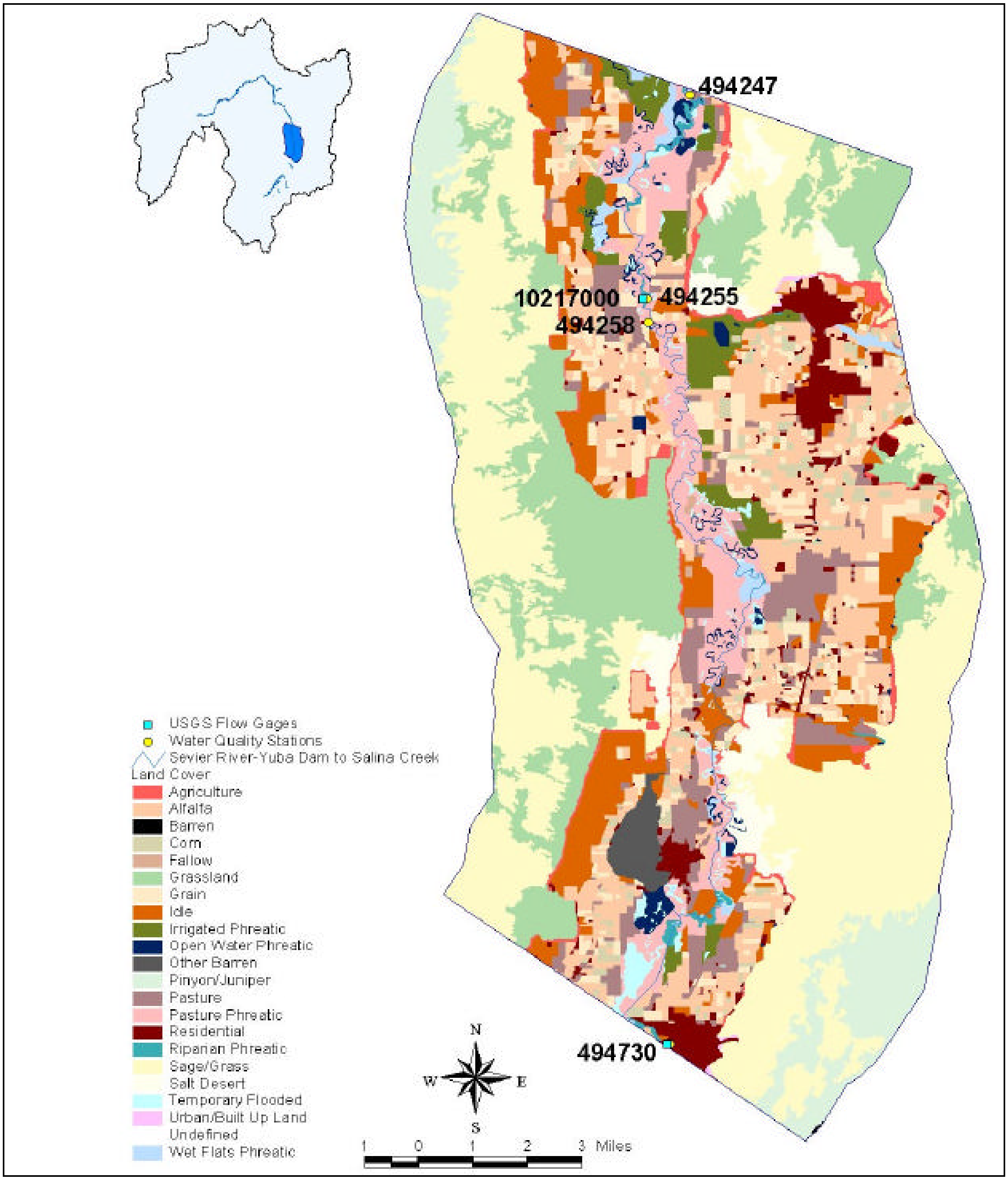

Figure 5-4. Land use along the Sevier River, Yuba Dam to the confluence with Salina Creek.

5.3.1 Sevier River (Yuba Dam to the confluence with Salina Creek): Total Dissolved Solids

Recent TDS data are available at three stations for the Sevier River between Yuba Dam and the confluence with Salina Creek (Table 5-3). Forty-four percent of the samples taken at these stations between 1996 and 2002 exceeded the 1,200 mg/L standard. Station 494247 is located above Yuba Reservoir southwest of Fayette and has the most TDS observations in this segment of the river. Values at this station are typically greatest and above the standard during the period April to September; winter samples are usually below the standard (Figure 5-5). There does not appear to be a long-term trend in TDS over the period of record (Figure 5-6).

Sevier River between Yuba Dam and Salina Creek

Table 5-3. Summary of TDS observations at stations on the Sevier River between Yuba Dam and Salina Creek.

Station	No. of Samples	Average	Min	Max	CV*	Min Date	Max Date
494247 (above Yuba Reservoir)	191	1,267	224	2,150	33%	2/8/75	8/1/02
494255 (below confluence with San Pitch River)	87	1,180	462	2,024	34%	5/19/80	3/16/93
494258 (west of Gunnison)	39	1,250	526	2,416	34%	5/24/78	6/24/97

*CV = coefficient of variation (standard deviation divided by the mean).

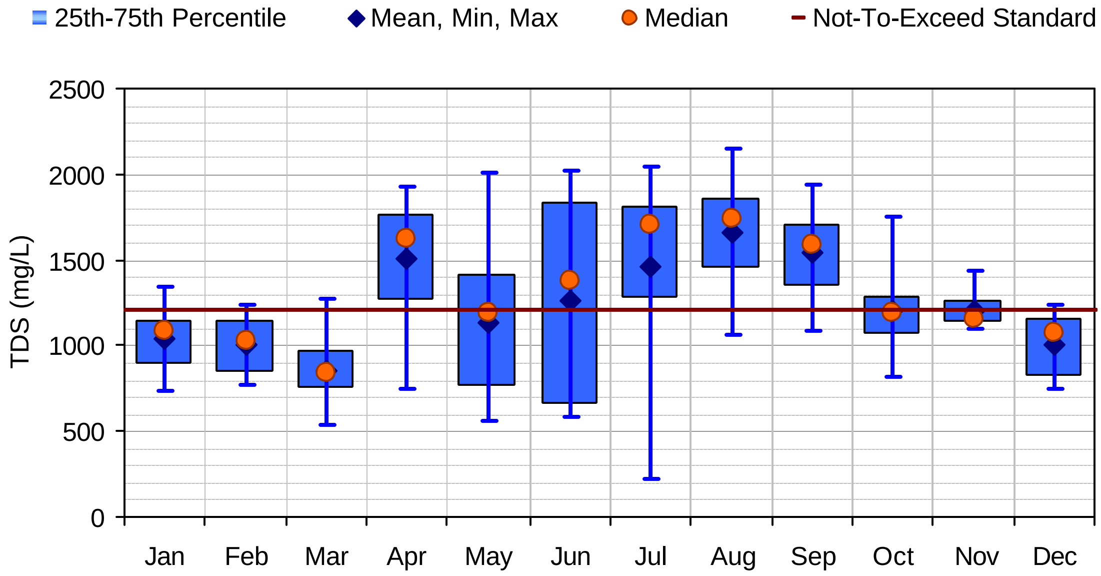

Figure 5-5. Monthly TDS concentrations at station 494247 (Sevier River above Yuba Reservoir). Data cover the period February 8, 1975 to August 1, 2002.

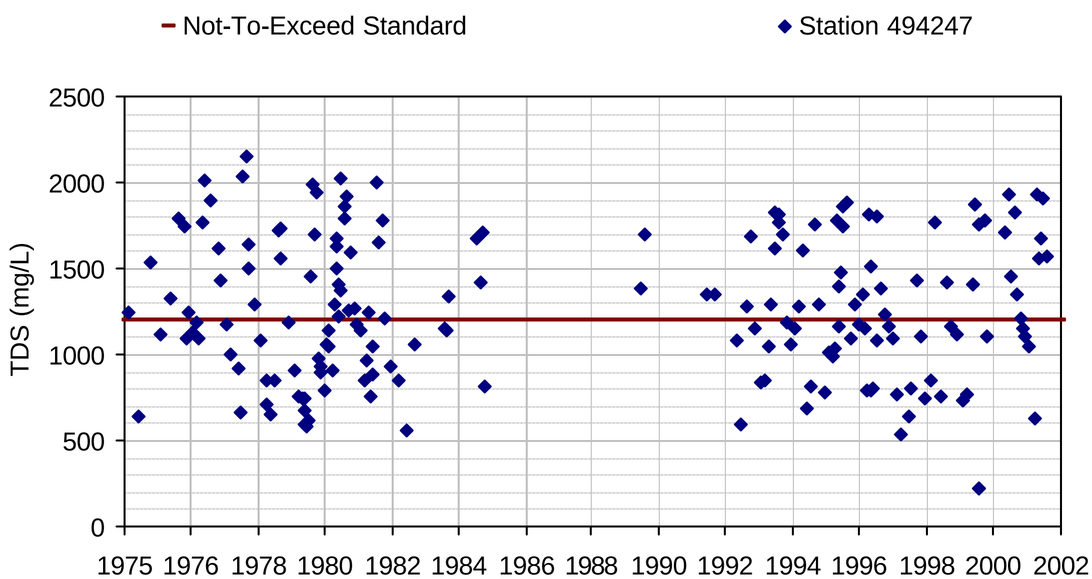

Figure 5-6. All TDS data for Station 494247 (above Yuba Reservoir).

The water quality data at station 494247 (above Yuba Reservoir) and the flow data at the USGS gage near Gunnison were used to determine existing and allowable TDS loads. The results of the load duration curve analysis are presented in Figure 5-7 and Table 5-4. They indicate that TDS loads above the loading capacity generally occur only during low flow periods. The greatest load reduction (approximately 126,000 kg/day) is needed for the 20th to 30th percentile flow groups. The critical conditions occur during July, August, and September when streamflows are decreasing, TDS concentrations are high, and water is likely to be needed for irrigation.

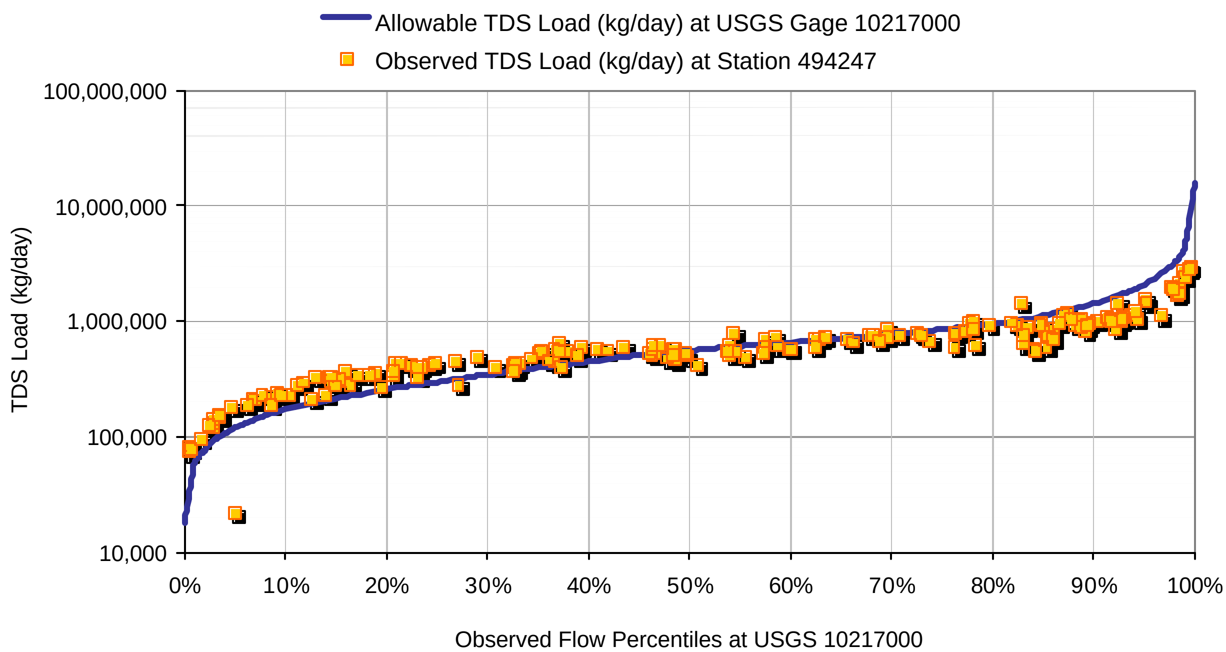

Figure 5-7. TDS Load Duration Curve for station 494247.

Table 5-4. TDS observed and allowable load for station 494247.

Flow Percentile Ranges	182-Sample Distribution	Median Observed Flow (cfs)	Observed Load (kg/day)	Observed Concentration (mg/L)	Allowable Load (kg/day)	Estimated Reduction (%)	Estimated Reduction (kg/day)
0-10	21	41	152,226	1,518	120,372	20.90%	31,854
10-20	18	73	304,491	1,705	214,320	29.60%	90,171
20-30	14	101	422,651	1,710	296,525	29.80%	126,126
30-40	18	134	477,141	1,455	393,409	17.50%	83,732
40-50	17	172	542,748	1,290	504,973	7.00%	37,775
50-60	14	205	577,979	1,152	601,858	0.00%	0
60-70	13	242	716,768	1,211	710,486	0.90%	6,282
70-80	13	289	795,357	1,125	848,472	0.00%	0
80-90	28	378	919,276	994	1,109,767	0.00%	0
90-100	26	707	1,478,417	855	2,075,675	0.00%	0

Significant sources of TDS in this segment of the Sevier River include irrigation return flows, land erosion, and natural and upstream loads. Table 5-5 summarizes the relative magnitude of each of these source categories. The calculations used to estimate the loads from each source category are described in section 4.2 above. The key assumptions used to derive the estimated loads for this segment of the river include the following:

?? 61,000 acres of irrigated lands
?? 36 inches of water applied per year
?? 40 percent efficiency for irrigation
?? 50 percent of unconsumed irrigated water returned to the river
?? concentration of 644 mg/L TDS from the Richfield lagoons and 453 from the Salina lagoons with seepage rates of 0.25 inches per day

?? average flow from the Rocky Ford Reservoir of 113 cfs and 671 mg/L TDS
?? soil loss parameters described in Section 4.2.4

Table 5-5. Summary of the sources of TDS loading in the Sevier River from Yuba Dam to the confluence with Salina Creek.

Source Category	Load (kg/yr)	Percent
Land Erosion/Natural Geology	113,052,040	49%
Upstream	67,669,660	29%
Irrigation Return Flows	50,978,050	22%
Richfield Lagoons	664,280	0.3%
Salina Lagoons	416,210	0.2%
Total	232,780,240	100%

The TDS TMDL for this segment of the Sevier River is summarized in Table 5-6 in terms of both endpoints and loads. Five percent of the loading capacity is reserved for a margin of safety as required by the Clean Water Act. Wasteload allocations for the two National Pollutant Discharge Elimination System (NPDES) facilities are set equal to zero.

Table 5-6. Summary of the TDS TMDL for the Sevier River from Yuba Dam to the confluence with Salina Creek.

Expressed as Endpoints					
?? 1,200 mg/L instream TDS target					
Expressed as Loads					
Existing Load (kg/yr)	**Loading Capacity (kg/yr)**	**WLA (kg/yr)**	**LA (kg/yr)**	**MOS (kg/yr)**	**Reduction (kg/yr)**
232,780,240	219,021,860	0	208,070,770	10,951,090	24,709,470

The load reductions in this segment of the river should be focused on the source categories associated with low flows. Example best management practices (BMPs) that should be implemented are shown in Table 5-7 and are described in more detail in Appendix A.

Table 5-7. Best management practices recommended for the Sevier River TDS TMDL between Yuba Dam and the confluence with Salina Creek.

Practice Number	Practice Name	Intensity Level	Time frame for Load Reduction	Maintenance
210	Exotic Removal	Active	Immediate	Medium
221	Seeding	Active	Months – Two Years	Low
260	Pole/Post Planting	Active	Months – Two Years	Low
440	Irrigation Land Leveling	Moderate Engineering	Months – Two Years	Low
450	Irrigation Pipeline	Moderate Engineering	Immediate	Low
452	Irrigation Sprinkler	Moderate	Immediate	Medium

A number of possible combinations of the above BMPs could result in meeting the targeted load reductions. Table 5-8 below provides details for only one of these possible combinations. The locally led Sevier River Steering and Technical Advisory Committee will provide guidance and direction for implementation activities needed to achieve the necessary load reductions. Therefore the approaches outlined in Table 5-8 are subject to change based on local input.

Table 5-8. Estimated impact of one potential set of best management practices for the Sevier River TDS TMDL between Yuba Dam and the confluence with Salina Creek.

Practice Number	Practice Name	Extent of Practice	Estimated Per Unit Load Reduction (kg/yr)	Resulting Load Reduction (kg/yr)
221	Seeding	Seed 10,000 acres to convert poorly vegetated pasture lands and barren lands to grasslands	550 kg/yr/acre reduction in TDS resulting from conversion of poorly vegetated lands to grasslands[1]	5,500,000
440	Irrigation Land Leveling	Utilize land leveling techniques for 15,000 acres, thus increasing efficiencies from 40 percent to 60 percent	300 kg/yr/acre reduction in TDS moving from 40 percent efficiency to 60 percent	4,500,000
450	Irrigation Pipeline	Install irrigation pipeline for 15,000 acres, thus increasing efficiencies from 40 percent to 60 percent	300 kg/yr/acre reduction in TDS moving from 40 percent efficiency to 60 percent	4,500,000
452	Irrigation Sprinkler	Convert approximately 10,000 acres of flood irrigation to sprinkler irrigation, thus increasing efficiencies from approximately 40 percent to 80 percent.	600 kg/yr/acre reduction in TDS moving from 40 percent efficiency to 60 percent	6,000,000
210	Exotic Removal	Eliminate 70 percent of salt cedar trees	NA[2]	NA
			Total Load Reduction	**20,500,000**

[1]Estimated load reduction based on lower USLE C-factors associated with grasslands compared to poorly vegetated lands.
[2]Few data are available with which to quantify the load reduction in TDS that would result from replacing salt cedar trees with native vegetation. However, there is widespread agreement that removing salt cedar should result in improved water quality, both due to reduced TDS loads and decreased evapotranspiration rates.

5.3.2 Sevier River (Yuba Dam to the confluence with Salina Creek): Sediment

Recent TSS data are available at three stations for the Sevier River between Yuba Dam and the confluence with Salina Creek (Table 5-9). Forty-six percent of the samples taken between 1996 and 2002 violated the interim water quality target of 90 mg/L. The most complete period of record is at Station 494247 (located above Yuba Reservoir). Values at this station are typically greatest in the spring (Figure 5-8). There does not appear to be a long-term trend in TSS over the period of record (Figure 5-9).

Table 5-9. Summary of total suspended solids (TSS) concentrations (mg/L) at stations on the Sevier River between Yuba Dam and the confluence with Salina Creek.

Station	No. of Samples	Average	Min	Max	CV*	Min Date	Max Date
494247 (above Yuba Reservoir)	162	320	0	9850	341%	2/5/76	8/1/02
494255 (below confluence with San Pitch River)	87	288	0	3660	172%	5/19/80	3/16/93
494258 (west of Gunnison)	36	216	12	1650	154%	9/6/78	6/24/97

*CV = coefficient of variation (standard deviation divided by the mean).

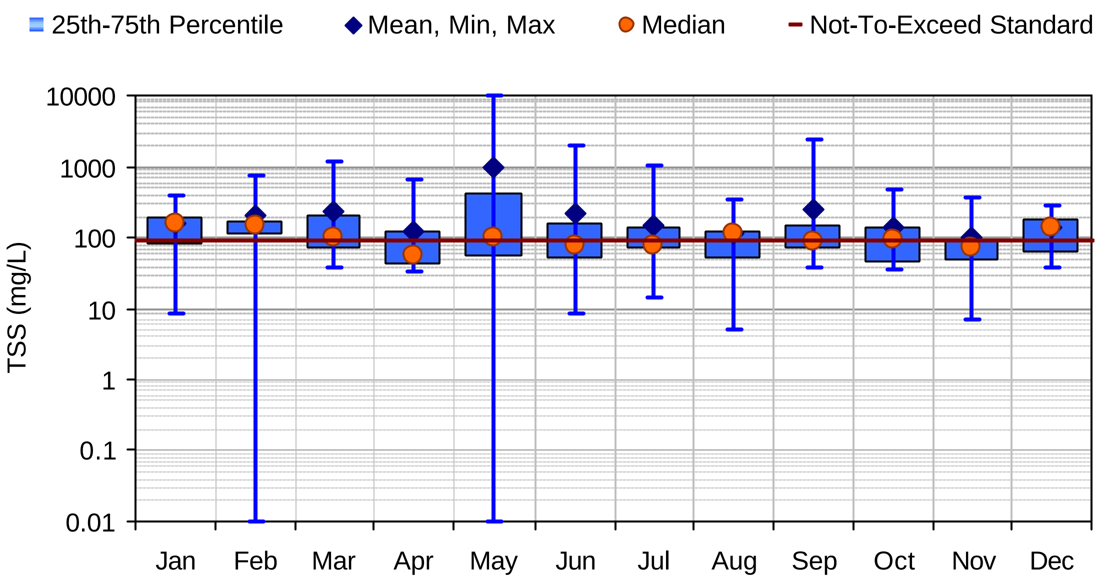

Figure 5-8. Monthly average TSS values at station 494247. Data cover the period February 5, 1976 to April 19, 2001.

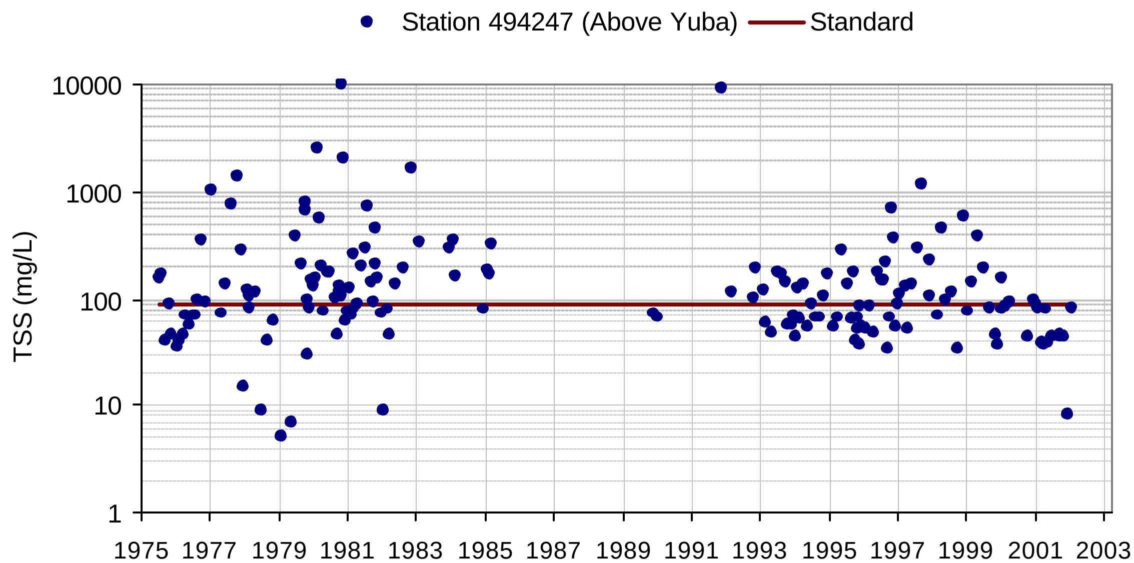

Figure 5-9. All TSS observations at station 494247.

The results of the load duration curve analysis for TSS are presented in Figure 5-10 and Table 5-10. Figure 5-10 shows that although individual TSS loads are rather variable across all flow percentiles, low flows (less than the 40th percentile) do not usually exceed the loading capacity. However, flows greater than the 40th percentile exceed the limit, indicating the need for reductions of TSS for most normal and high flow periods in this segment of the Sevier River. The greatest load reductions are needed for the 90th to 100th percentile flow group.

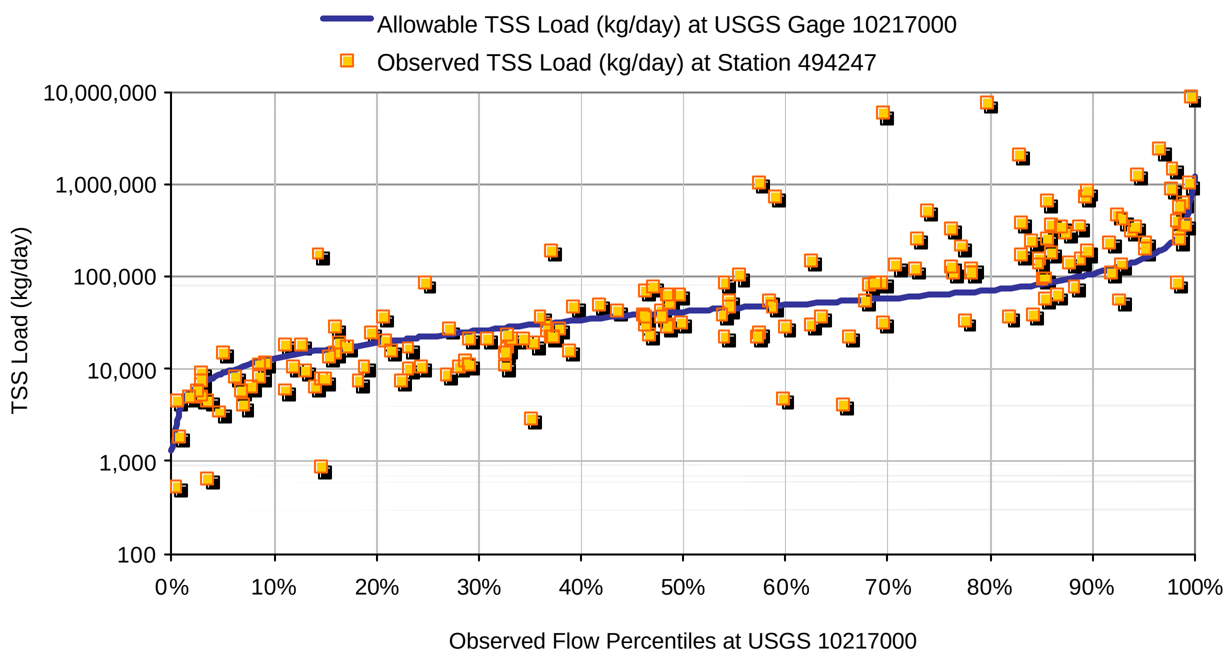

Figure 5-10. TSS Load Duration Curve for station 494247.

Table 5-10. TSS Observed and Allowable Loads for station 494247.

Flow Percentile Ranges	182-Sample Distribution	Median Observed Flow (cfs)	Observed Load (kg/day)	Observed Concentration (mg/L)	Allowable Load (kg/day)	Estimated Reduction (%)	Estimated Reduction (kg/day)
0-10	20	41	5,597	56	9,028	0.00%	0
10-20	18	73	12,326	69	16,074	0.00%	0
20-30	14	101	14,235	58	22,239	0.00%	0
30-40	19	134	21,734	66	29,506	0.00%	0
40-50	16	172	44,195	105	37,873	14.30%	6,322
50-60	14	205	47,550	95	45,139	5.10%	2,411
60-70	12	242	46,788	79	53,286	0.00%	0
70-80	13	289	129,913	184	63,635	51.00%	66,278
80-90	26	378	190,030	205	83,233	56.20%	106,797
90-100	23	707	376,039	217	155,676	58.60%	220,363

The major sources of TSS in this segment of the Sevier River include streambank erosion, sheet/rill erosion, and upstream sources. The key assumptions used to derive the estimated loads for this segment of the river include the following:

- poor streambank conditions based on poor vegetation, flow modifications, and highly erodible soils
- bank erosion rate of 0.25 feet/year
- average bank height of 6 feet
- 29 stream miles between Salina Creek and Yuba Dam
- average flow from the Rocky Ford Reservoir of 113 cfs and 117 mg/L TSS
- soil loss parameters described in Section 4.2.4

Table 5-11. Summary of the sources of TSS loading in the Sevier River from Yuba Dam to the confluence with Salina Creek.

Source Category	Load	Percent
Land Erosion/Natural Geology	13,055,730	40%
Upstream	11,799,330	36%
Streambank Erosion	7,479,400	23%
Annual TSS Load	**32,334,460**	**100%**

The TSS TMDL for this segment of the Sevier River is summarized in Table 5-12. Load reductions for the 90th to 100th flow percentile are not included because of the extreme difficulty of achieving the standard during these flood conditions. In essence, the 10 percent exceedances of water quality samples that the state allows are allocated to these flood conditions. The critical conditions occur during December to May when TSS concentrations are highest and when spring spawning is occurring for some resident fish.

Five percent of the loading capacity is reserved for a margin of safety. The wasteload allocation for the NPDES facilities is set to zero (no allowable load). Approximately a 21 percent reduction in current loads is needed to meet the loading capacity. These reductions should be focused on those sources associated with wet weather events because those are the critical conditions.

Table 5-12. Summary of the TSS TMDL for the Sevier River from Yuba Dam to the confluence with Salina Creek.

Expressed as Interim Water Quality Goals	
?? Documented improvement in health of macroinvertebrate communities	?? 90 mg/L instream TSS target ?? Documented improved riparian habitat conditions as measured using an appropriate habitat scoring methodology

Existing Load (kg/yr)	Loading Capacity (kg/yr)	WLA (kg/yr)	LA (kg/yr)	MOS (kg/yr)	Reduction (kg/yr)
32,334,460	26,799,760	0	25,459,770	1,339,990	6,874,690

BMPs that should be implemented in this section of the river are shown in Table 5-13. One possible combination of BMPs is shown in Table 5-14. The total load reduction shown in Table 5-14 relies on reducing land and streambank erosion in the listed reach, as well as on decreasing concentrations in the discharge from Rocky Ford Reservoir since this is a significant component of the existing load. These upstream reduced concentrations could be reasonably expected if efforts were made to reduce shoreline erosion in the reservoir and to apply the same types of BMPs upstream that are proposed downstream (e.g., seeding, streambank restoration). The locally led Sevier River Steering and Technical Advisory Committee will need to provide final direction for implementation activities needed to achieve the necessary load reductions. Therefore the approaches outlined in Table 5-14 are subject to change based on local input.

Table 5-13. Best management practices recommended for the Sevier River TSS TMDL between Yuba Dam and the confluence with Salina Creek.

Practice Number	Practice Name	Intensity Level	Time frame for Load Reduction	Maintenance
221	Seeding	Active	Months – Two Years	Low
304	Vertical Bundle	Mild Engineering	Months – Two Years	Low
305	Willow Fascines	Mild Engineering	Months – Two Years	Low
260	Pole/Post Planting	Active	Months – Two Years	Low
210	Exotic Removal	Active	Immediate	Medium

Table 5-14. Estimated impact of one potential set of best management practices for the Sevier River TSS TMDL between Yuba Dam and the confluence with Salina Creek.

Practice Number	Practice Name	Extent of Practice	Estimated Per Unit Load Reduction (kg/yr)	Resulting Load Reduction (kg/yr)
221	Seeding	Seed 10,000 acres to convert pasture lands and barren lands to grasslands	70 kg/yr/acre reduction in TSS resulting from conversion of poorly vegetated lands to grasslands[1]	700,000
260	Pole/Post Planting	Re-establish vegetation along 20 miles of most severely eroding streambanks	154,750 kg/yr reduction in TSS for every 1 mile of stabilized streambanks[2]	3,095,000
N/A	N/A	Reduce shoreline erosion in Rocky Ford Reservoir and upstream sources to the point that discharge from the reservoir is 90 mg/L instead of 117 mg/L	N/A	2,722,920
			Total Load Reduction	**6,517,920**

[1]Estimated load reduction based on lower USLE C-factors associated with grasslands compared to poorly vegetated lands.
[2]Estimated load reduction based on reducing near bank stress from moderate-high (0.25 feet/year) to low (0.1 feet/year).

5.3.3 Sevier River (Yuba Dam to the confluence with Salina Creek): Phosphorus

Recent TP data are available at three stations for the Sevier River between Yuba Dam and the confluence with Salina Creek (Table 5-15). Eighty percent of the samples taken between 1996 and 2002 exceeded 0.05 mg/L. The most complete period of record is at Station 494247 (above Yuba Reservoir). Values at this station are typically highest in the winter and early spring (Figure 5-11). There does not appear to be a long-term trend in TP over the period of record (Figure 5-12).

Table 5-15. Summary of available TP data on the Sevier River between Yuba Dam and Salina Creek.

Station	No. of Samples	Average	Min	Max	CV*	Min Date	Max Date
494247 (above Yuba Reservoir)	151	0.16	0.010	2.70	187%	7/15/76	8/1/02
494255 (below confluence with San Pitch River)	86	0.16	0.003	1.00	112%	5/19/80	3/16/93
494258 (west of Gunnison)	23	0.18	0.005	2.00	232%	8/22/79	4/22/97

*CV = coefficient of variation (standard deviation divided by the mean).

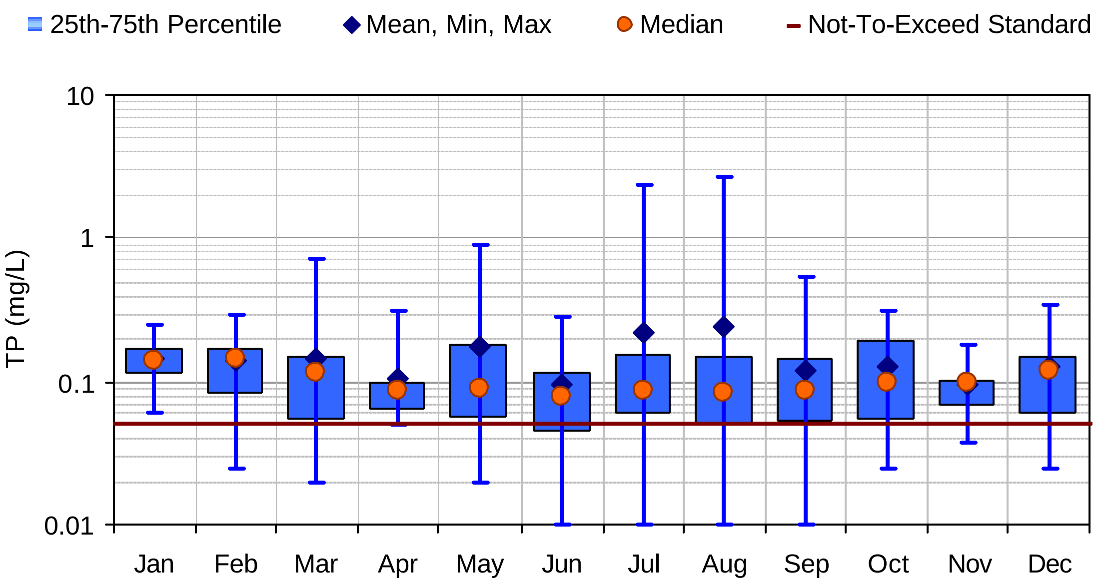

Figure 5-11. Monthly TP concentrations at station 494247. Data cover the period July 15, 1976 to August 1, 2002.

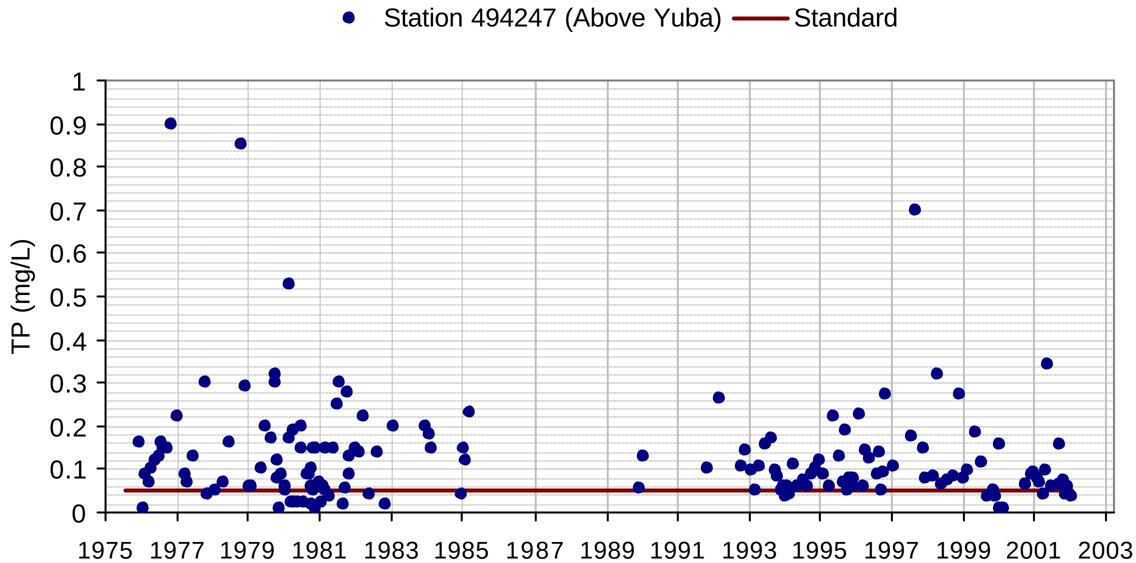

Figure 5-12. All TP observations at station 494247. <add name of station>

The results of the TP load duration analysis for this segment of the Sevier River are shown in Figure 5-13 and Table 5-16. Figure 5-13 shows that TP loads vary widely throughout the flow record. However, all but the lowest percentile groups exceed the loading capacity limit, indicating the need for reductions of TP for most flows for this segment of the Sevier River. The greatest load reductions are needed for the highest flow percentile.

The critical condition for TP is the late summer (July, August, September) because this is the period when factors are most conducive to excessive plant growth (e.g., lots of sunlight, lower flows, higher temperatures).

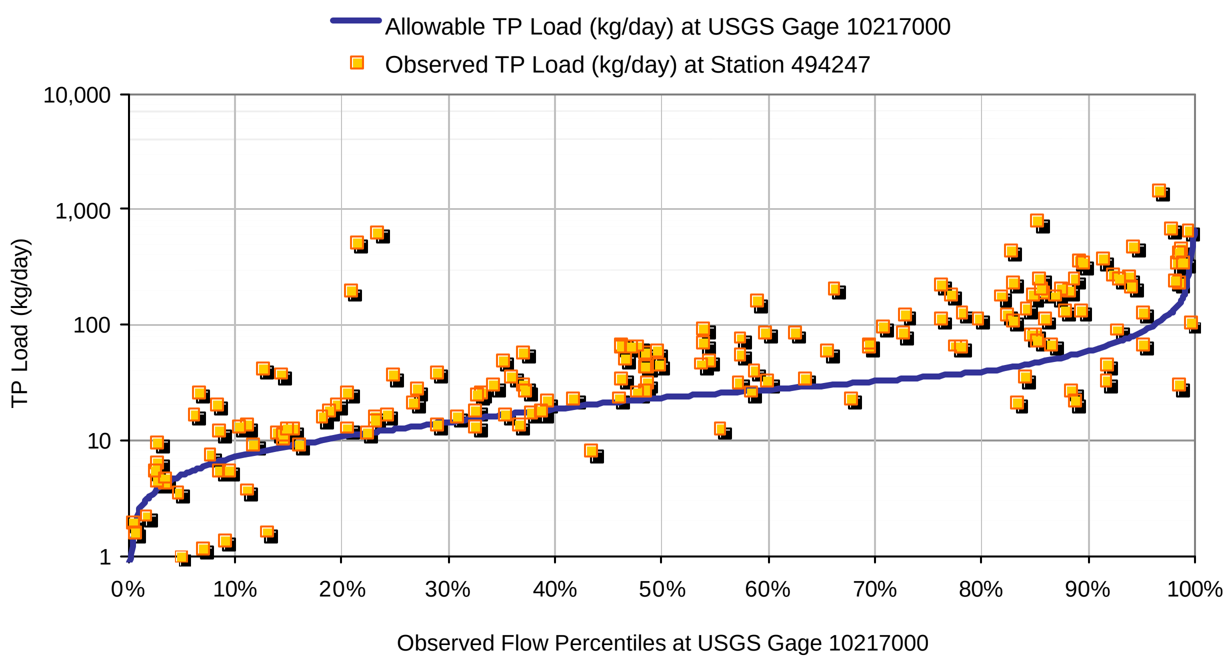

Figure 5-13. TP Load Duration Curve for station 494247.

Table 5-16. TP Observed and Allowable Loads for Station 494247.

Flow Percentile Ranges	165-Sample Distribution	Median Observed Flow (cfs)	Observed Load (kg/day)	Observed Concentration (mg/L)	Allowable Load (kg/day)	Estimated Reduction (%)	Estimated Reduction (kg/day)
0-10	21	41	5	0.05	5	0.00%	0
10-20	16	73	13	0.07	9	30.00%	4
20-30	14	101	24	0.10	12	48.40%	12
30-40	17	134	25	0.08	16	34.90%	9
40-50	16	172	44	0.10	21	51.90%	23
50-60	13	205	50	0.10	25	49.50%	25
60-70	8	242	63	0.11	30	53.20%	33
70-80	10	289	115	0.16	35	69.30%	80
80-90	28	378	161	0.17	46	71.30%	115
90-100	22	707	258	0.15	86	66.50%	172

There are many sources of TP in this segment of the Sevier River including livestock, lagoons, and upstream sources. Table 5-17 summarizes the relative magnitude of each of these source categories based on the following key assumptions:

?? 61,000 acres of irrigated lands
?? 36 inches of water applied per year
?? 40 percent efficiency for irrigation
?? 50 percent of unconsumed irrigated water returned to the river
?? 4,500 animal units spending 6 months in feedlots or forest and 6 months in wet meadow pastures
?? 7,000 septic systems
?? poor streambank conditions based on poor vegetation, flow modifications, and highly erodible soils
?? bank erosion rate of 0.25 feet/year
?? average bank height of 6 feet
?? 29 stream miles between Salina Creek and Yuba Dam
?? 400 mg/kg phosphorus content of streambank soils
?? concentration of 4 mg/L TP from the Richfield and Salina lagoons
?? average flow from the Rocky Ford Reservoir of 113 cfs and 0.086 mg/L TP

Table 5-17. Summary of the sources of TP loading in the Sevier River from Yuba Dam to the confluence with Salina Creek.

Source Category	Load (kg/yr)	Percent
Upstream	8,670	31%
Livestock	4,140	15%
Richfield Lagoon	4,120	15%
Salina Lagoon	3,670	13%
Streambank Erosion	2,990	11%
Land Erosion/Natural Geology	1,870	7%
Irrigation	1,700	6%
Septic Systems	430	2%
Total	**27,590**	**100%**

The TP TMDL for this segment of the Sevier River is summarized in Table 5-18. Load reductions for the 90th to 100th flow percentile are not included because of the extreme difficulty of achieving the standard during these high flow conditions. In essence, the 10 percent exceedance of water quality samples that the state allows are allocated to these flood conditions.

Five percent of the loading capacity is reserved for a margin of safety. The wasteload allocation for each of the NPDES facilities is set to zero.

Table 5-18. Summary of the TP TMDL for the Sevier River from Yuba Dam to the confluence with Salina Creek.

Expressed as Endpoints					
?? 0.05 mg/L instream TP target			?? Documented improved riparian habitat conditions as measured using an appropriate habitat scoring methodology		
Expressed as Loads					
Existing Load (kg/yr)	**Loading Capacity (kg/yr)**	**WLA (kg/yr)**	**LA (kg/yr)**	**MOS (kg/yr)**	**Reduction (kg/yr)**
27,590	16,670	0	15,840	830	11,750

BMPs recommended for the necessary TP nonpoint source reductions are shown in Table 5-19. These reductions should be focused across all source categories and flow conditions. It should be noted that some BMPs should be implemented upstream of this segment to try and reduce upstream loads.

Table 5-19. Best management practices recommended for the Sevier River TP TMDL between Yuba Dam and the confluence with Salina Creek.

Practice Number	Practice Name	Intensity Level	Time frame for Load Reduction	Maintenance
221	Seeding	Active	Months – Two Years	Low
260	Pole/Post Planting	Active	Months – Two Years	Low
210	Exotic Removal	Active	Immediate	Medium
220	Fencing	Active Management	Immediate	Low
120	Grazing Management	Passive Management	Months – Two Years	Low

A number of possible combinations of the above BMPs could result in meeting the targeted load reductions. Table 5-20 below provides details for only one of these possible combinations. The locally led Sevier River Steering and Technical Advisory Committee will provide guidance and direction for implementation activities needed to achieve the necessary load reductions. Therefore the approaches outlined in Table 5-20 are subject to change based on local input.

Table 5-20. Estimated impact of one potential set of best management practices for the Sevier River TP TMDL between Yuba Dam and the confluence with Salina Creek.

Practice Number	Practice Name	Extent of Practice	Estimated Per Unit Load Reduction (kg/yr)	Resulting Load Reduction (kg/yr)
221	Seeding	Seed 10,000 acres to convert poorly vegetated pasture lands and barren lands to grasslands	0.1 kg/yr/acre reduction in TP resulting from conversion of poorly vegetated lands to grasslands[1]	1,000
260	Pole/Post Planting	Re-establish vegetation along 20 miles of most severely eroding streambanks	60 kg/yr reduction in TP for every 1 mile of stabilized streambanks[2]	1,200
450	Irrigation Pipeline	Install irrigation pipeline for 15,000 acres, thus increasing efficiencies from 40 percent to 60 percent	0.014 kg/yr/acre reduction in TP moving from 40 percent efficiency to 60 percent	210
N/A	N/A	Eliminate failing septic systems	N/A	430
220	Fencing	Eliminate loads from livestock	N/A	4,140
N/A	N/A	Reduce upstream sources to the point that discharge from Rocky Ford Reservoir meets water quality standards	N/A	3,630
			Total Load Reduction	**10,610**

[1]Estimated load reduction based on lower USLE C-factors associated with grasslands compared to poorly vegetated lands.
[2]Estimated load reduction based on reducing near bank stress from moderate-high (0.25 feet/year) to low (0.1 feet/year).

5.4 Sevier River from DMAD Reservoir to the Yuba Dam

The Sevier River from the DMAD Reservoir to the Yuba Dam is listed for sediment, total phosphorus, and habitat alteration. The listing for habitat alterations is closely related to the sediment and total phosphorus listings because all three are associated with altered streamflows and significant streambank destabilization. Numerous researchers have shown a direct link between poor habitat conditions and increased streambank erosion (e.g., Rosgen, 1996; Leopold et al., 1964). Because it is not entirely appropriate to develop a TMDL for habitat, only sediment and phosphorus TMDLs are presented in this document. However, many of the BMPs recommended to reduce loads of these pollutants are also expected to improve habitat conditions (e.g., remove tamarisk trees, improve streambank conditions).

The Sevier River from DMAD Reservoir to the U-132 crossing is also listed for TDS. Figure 5-14 displays land uses/land cover along the Sevier River from U-132 crossing to Yuba Dam and Figure 5-15 displays land uses/land cover along the Sevier River from DMAD Reservoir to the U-132 crossing. The dominant land uses/cover are sage/grass, grassland, and salt desert.

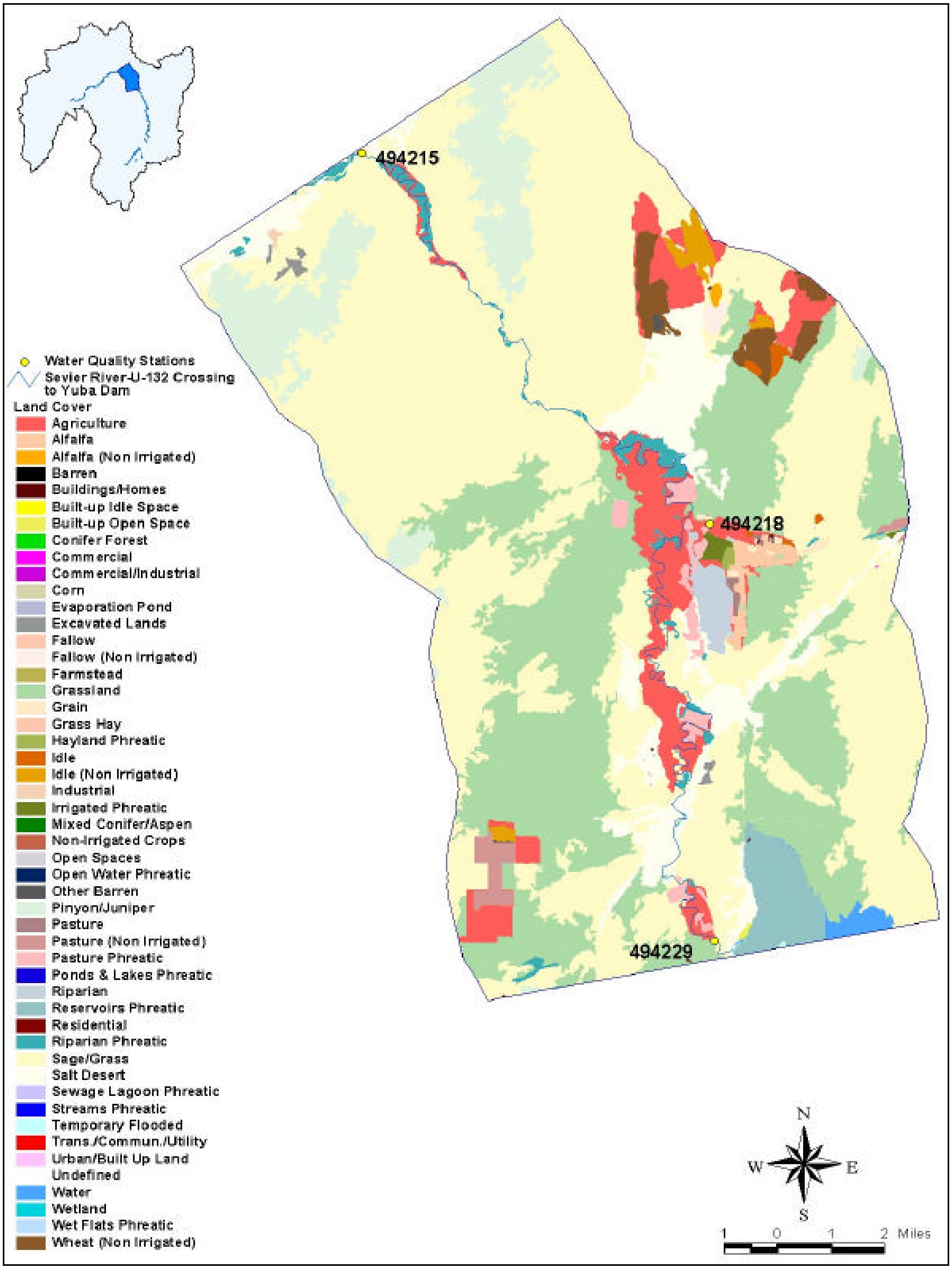

Figure 5-14. Land use and land cover within the buffer zone along the Sevier River – U-132 Crossing to Yuba Dam.

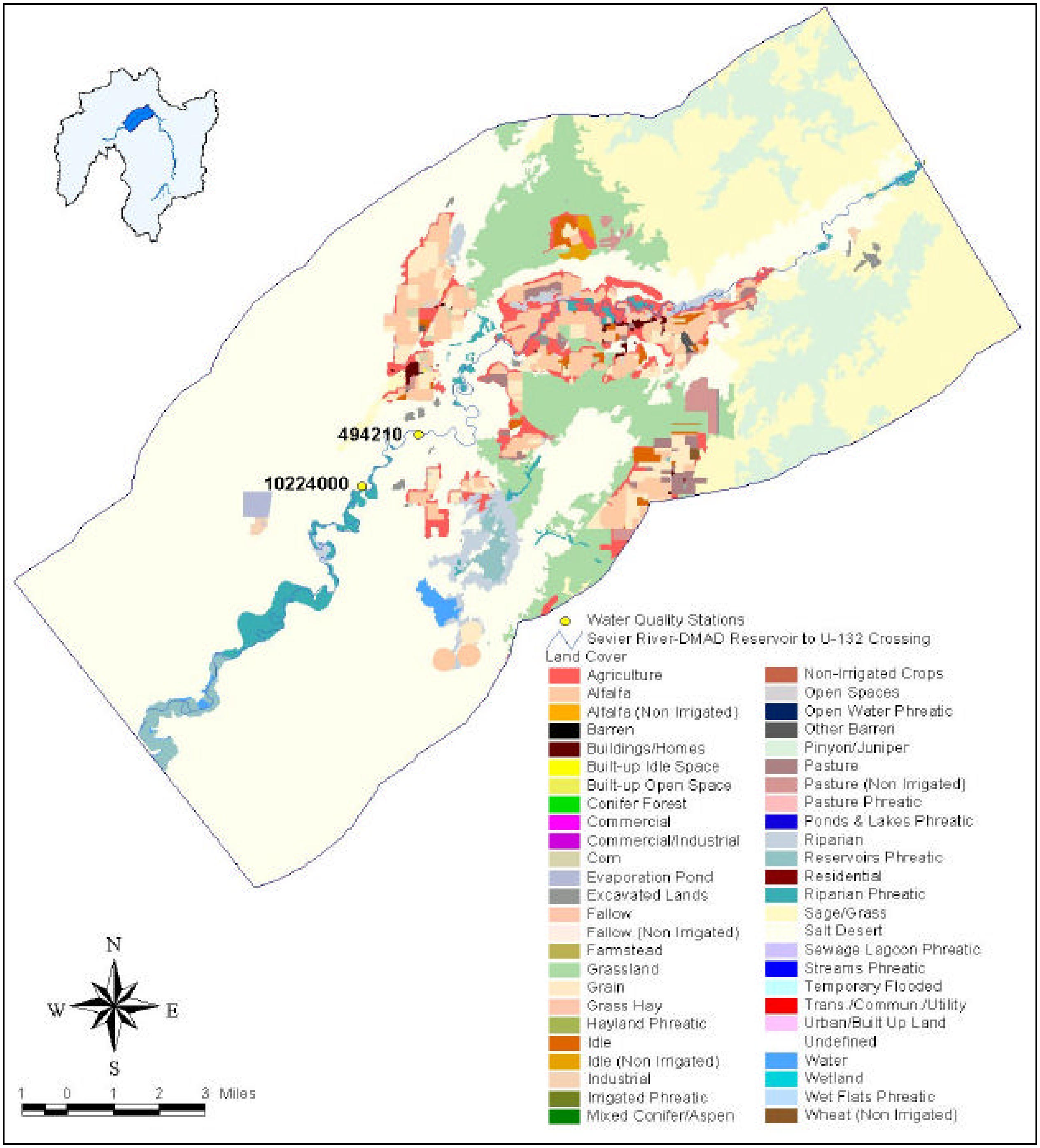

Figure 5-15. Land use and land cover within the buffer zone along the Sevier River – Yuba Dam to DMAD Reservoir.

5.4.1 Sevier River from DMAD Reservoir to the Yuba Dam: Total Phosphorus

Recent total phosphorus data are available at four stations for the Sevier River between DMAD Reservoir and the Yuba Dam (Table 5-21). Twenty-nine percent of the samples taken at these stations between 1996 and 2002 violated the 0.05 mg/L standard. Station 494210 is located 1.5 miles south of Lynndyl on the Sevier River and has the most TP observations in this segment of the river. Values at this station are typically greatest during the early summer. Average values in the late summer and winter are usually below the guideline (Figure 5-16). The critical conditions are during the summer when climatic conditions are most conducive to plant growth and TP concentrations are high. There does not appear to be a long-term trend in TP over the period of record (Figure 5-17).

Table 5-21. Available TP data for the Sevier River between Yuba Dam and the U-132 crossing.

Station	No. of Samples	Average	Min	Max	CV*	Min Date	Max Date
494215 (at U-132 crossing)	128	0.05	0.003	0.25	87%	11/17/77	6/11/02
494229 (below Yuba Reservoir)	97	0.05	0.003	0.36	110%	4/22/80	4/8/93
494210 (south of Lynndyl)	168	0.06	0.003	0.42	86%	9/7/76	7/30/02
10224000 (USGS gage near Lynndyl)	141	0.07	0.000	0.49	118%	10/9/74	8/16/94

*CV = coefficient of variation (standard deviation divided by the mean).

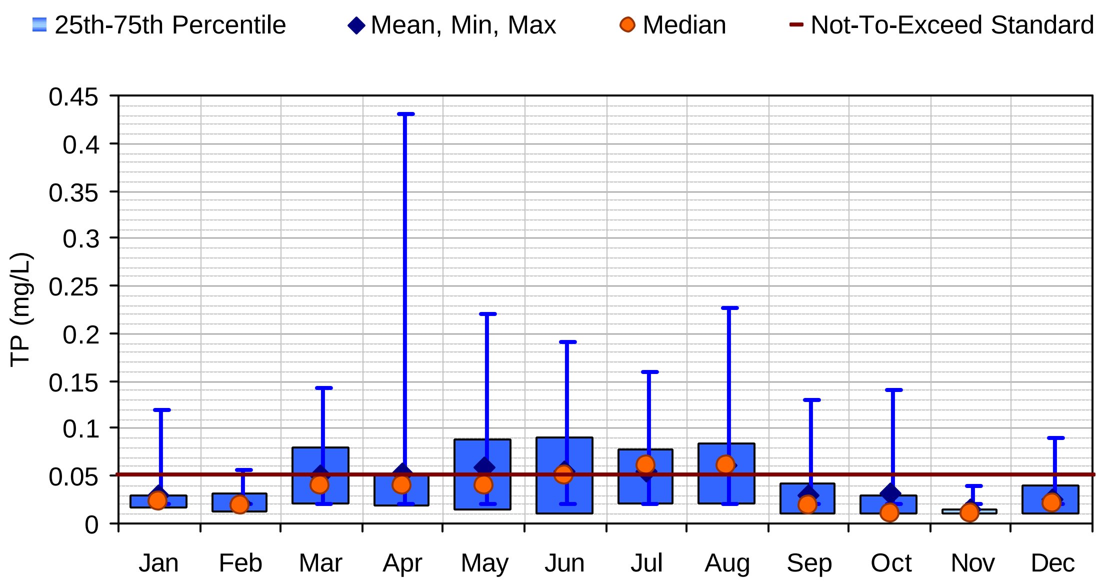

Figure 5-16. Monthly TP data for station 494210 (south of Lynndyl). Data cover the period September 7, 1976 to July 30, 2002.

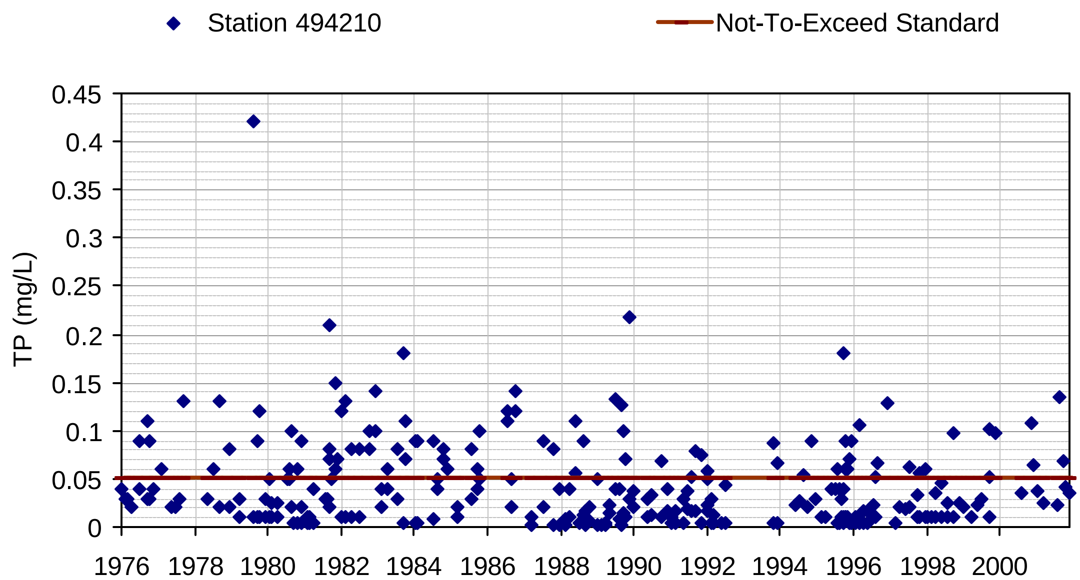

Figure 5-17. All TP data at station 494210 (south of Lynndyl).

The load duration analysis was completed for this segment of the Sevier River using the water quality data from station (494210) and the flow from the UGSG gage at 1022400. Both of these stations are located near Lynndyl.

The results of the load duration analysis are shown in Figure 5-18 and Table 5-22 and indicate that most flows greater than the 60th percentile flow have a median load above the loading capacity limit. The greatest load reductions are needed for the 90th to 100th percentile flow group.

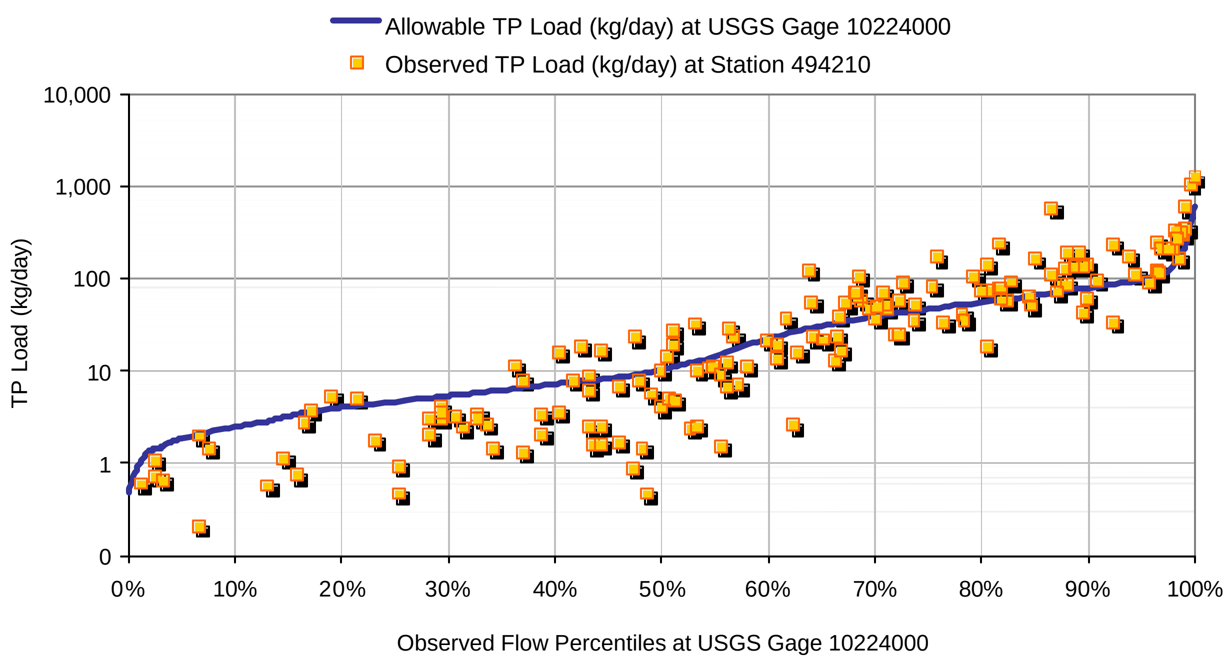

Figure 5-18. Total phosphorus load duration curve for the Sevier River between DMAD Reservoir and Yuba Reservoir.

Table 5-22. Total phosphorus observed and allowable loads for the Sevier River between DMAD Reservoir and Yuba Reservoir.

Flow Percentile Ranges	162-Sample Distribution	Median Observed Flow (cfs)	Observed Load (kg/day)	Observed Concentration (mg/L)	Allowable Load (kg/day)	Estimated Reduction (%)	Estimated Reduction (kg/day)
0-10	8	15	1	0.03	2	0.00%	0
10-20	6	26	2	0.03	3	0.00%	0
20-30	10	38	3	0.03	5	0.00%	0
30-40	11	50	3	0.02	6	0.00%	0
40-50	21	67	6	0.04	8	0.00%	0
50-60	21	118	11	0.04	14	0.00%	0
60-70	20	249	39	0.06	30	20.90%	9
70-80	17	380	51	0.05	46	8.40%	5
80-90	26	535	87	0.07	65	25.00%	22
90-100	21	787	219	0.11	96	56.10%	123

The major sources of TP in this segment of the Sevier River include upstream loads, livestock, and land erosion/streambank erosion. Table 5-23 summarizes the relative magnitude of each of these source categories based on the following key assumptions:

- 2,000 animal units spending 6 months in pasture and 6 months in feedlots
- 900 septic systems
- bank erosion rate of 0.2 feet/year
- average bank height of 6 feet
- 76 stream miles between Yuba Dam and DMAD Reservoir
- average flows of 262 cfs and 0.047 mg/L TP from the Yuba Dam

Table 5-23. Summary of the sources of TP loading in the Sevier River from DMAD Reservoir to the Yuba Dam.

Source Category	Load	Percent
Land Erosion/Natural Geology	5,780	38%
Upstream	5,490	36%
Streambank Erosion	3,140	20%
Livestock	610	4%
Irrigation Return Flows	210	1%
Septic Systems	110	1%
Total	15,340	100%

The TP TMDL for this segment of the Sevier River is summarized in Table 5-24. There are no NPDES facilities so the wasteload allocation is set to zero. Approximately a 10 percent reduction in current loads is needed to meet the loading capacity.

Table 5-24. Summary of the TP TMDL for the Sevier River from DMAD Reservoir to the Yuba Dam.

Expressed as Endpoints					
?? 0.05 mg/L instream TP target ?? Documented improvement in the health of the macroinvertebrate communities			?? Documented improved riparian habitat conditions as measured using an appropriate habitat scoring methodology		
Existing Load (kg/yr)	**Loading Capacity (kg/yr)**	**WLA (kg/yr)**	**LA (kg/yr)**	**MOS (kg/yr)**	**Reduction (kg/yr)**
15,340	14,550	0	13,820	730	1,520

Potential BMPs to achieve the necessary load reductions are listed in Table 5-25. A number of possible combinations of the above BMPs could result in meeting the targeted load reductions. Table 5-26 below provides details for only one of these possible combinations. The locally led Sevier River Steering and Technical Advisory Committee will provide guidance and direction for implementation activities needed to achieve the necessary load reductions. Therefore the approaches outlined in Table 5-26 are subject to change based on local input. The critical condition is during the high water period associated with dam releases in the summer because this is when TP concentrations are highest and when conditions are most conducive to excessive plant growth.

Table 5-25. Best management practices recommended for the Sevier River TP TMDL between DMAD Reservoir and Yuba Dam.

Practice Number	Practice Name	Intensity Level	Time frame for Load Reduction	Maintenance
260	Pole/Post Planting	Active	Months – Two Years	Low
210	Exotic Removal	Active	Immediate	Medium
220	Fencing	Active Management	Immediate	Low
120	Grazing Management	Passive Management	Months – Two Years	Low

Table 5-26. Estimated impact of one potential set of best management practices for the Sevier River TP TMDL between DMAD Reservoir and Yuba Dam.

Practice Number	Practice Name	Extent of Practice	Estimated Per Unit Load Reduction (kg/yr)	Resulting Load Reduction (kg/yr)
221	Seeding	Seed 7,500 acres to convert poorly vegetated pasture lands and barren lands to grasslands	0.1 kg/yr/acre reduction in TP resulting from conversion of poorly vegetated lands to grasslands[1]	750
260	Pole/Post Planting	Re-establish vegetation along 4 miles of most severely eroding streambanks	60 kg/yr reduction in TP for every 1 mile of stabilized streambanks[2]	240
N/A	N/A	Eliminate failing septic systems	N/A	110
120	Grazing Management	Eliminate loads from livestock	N/A	610
			Total Load Reduction	**1710**

[1]Estimated load reduction based on lower USLE C-factors associated with grasslands compared to poorly vegetated lands.
[2]Estimated load reduction based on reducing near bank stress from moderate-high (0.25 feet/year) to low (0.1 feet/year).

5.4.2 Sevier River from DMAD Reservoir to Yuba Dam: Sediment

Recent TSS data are available at 3 stations for the Sevier River between DMAD Reservoir and Yuba Dam (Table 5-27). Fifteen percent of the samples taken at these stations between 1996 and 2002 exceeded the interim water quality target of 90 mg/L. The most complete period of record is at Station 494210 (south of Lynndyl). Values at this station are typically greatest in the spring (Figure 5-19) and there does not appear to be a long-term trend in TSS over the period of record (Figure 5-20).

Table 5-27. Available Sediment Data for the Sevier River between DMAD Reservoir and the Yuba Dam.

Station	No. of Samples	Average	Min	Max	CV*	Min Date	Max Date
494215 (at U-132 crossing)	139	45	0	350	125%	11/17/77	6/11/02
494229 (below Yuba Reservoir)	100	17	0	112	105%	5/11/76	4/8/93
494210 (south of Lynndyl)	187	72	0	834		9/7/76	7/30/02

*CV = coefficient of variation (standard deviation divided by the mean).

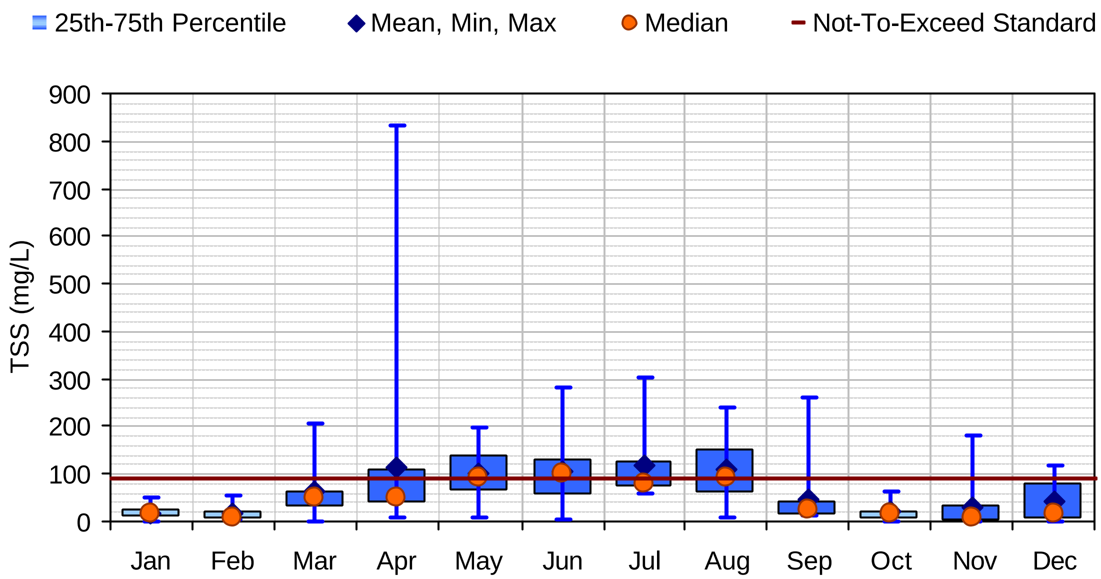

Figure 5-19. Monthly TSS concentrations at station 494210 (south of Lynndyl). Data cover the period September 7, 1976 to July 30, 2002.

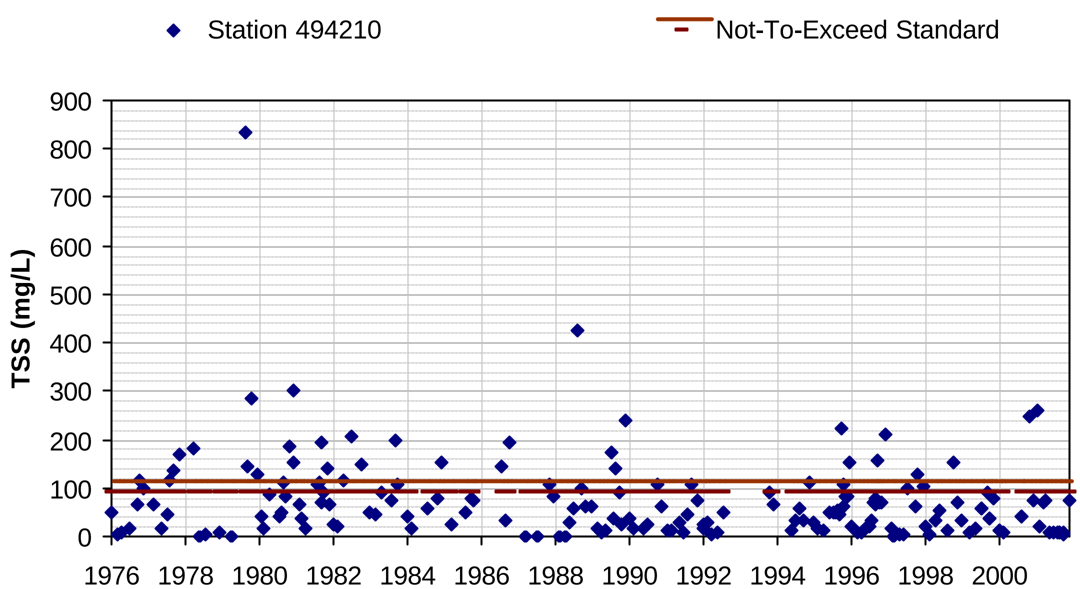

Figure 5-20. All TSS Data at station 494210 (south of Lynndyl). Data cover the period September 7, 1976 to July 30, 2002.

The results of the TSS load duration analysis for this segment of the Sevier River are shown in Figure 5-21 and Table 5-28. Figure 5-21 shows that although the observed data are quite scattered, only the highest flows (greater than the 80th percentile) have a load above the loading capacity limit, suggesting that TSS loading violations are related to wet weather flows. The need for reductions of TSS, therefore, is associated with the highest flow frequencies for this segment of the Sevier River. The greatest load reductions are needed for the 90th to 100th percentile flow group. The critical months are the spring spawning season.

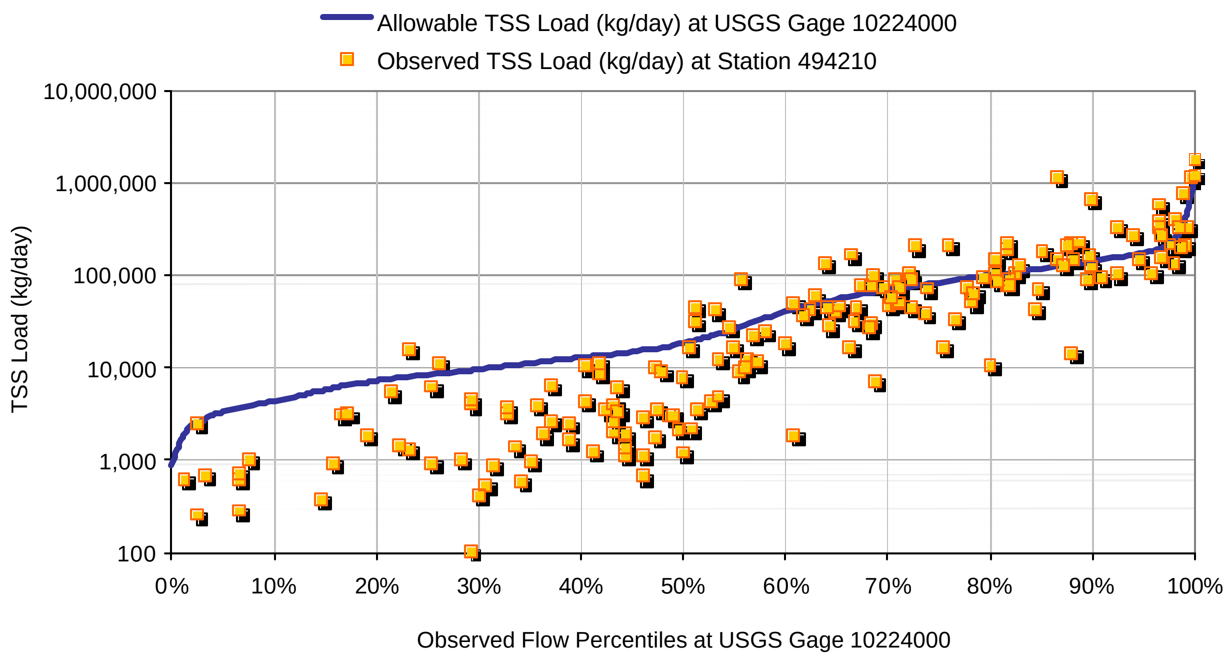

Figure 5-21. TSS Load Duration Curve at Station 494210 (south of Lynndyl).

Table 5-28. TSS observed and allowable loading at station 494210 (south of Lynndyl).

Flow Percentile Ranges	177-Sample Distribution	Median Observed Flow (cfs)	Observed Load (kg/day)	Observed Concentration (mg/L)	Allowable Load (kg/day)	Estimated Reduction (%)	Estimated Reduction (kg/day)
0-10	8	15	669	18	3,303	0.00%	0
10-20	6	26	2,536	40	5,725	0.00%	0
20-30	12	38	4,329	47	8,367	0.00%	0
30-40	14	50	1,809	15	11,010	0.00%	0
40-50	27	67	3,053	19	14,753	0.00%	0
50-60	20	118	14,949	52	25,983	0.00%	0
60-70	22	249	44,654	73	54,828	0.00%	0
70-80	19	380	64,654	70	83,673	0.00%	0
80-90	27	535	128,112	98	117,803	8.00%	10,309
90-100	21	787	276,702	144	173,291	37.40%	103,411

Sources of TSS in this segment of the Sevier River include upstream loads, land erosion, and streambank erosion. Table 5-29 summarizes the relative magnitude of each of these source categories based on the following key assumptions:

?? Upstream loads from the Yuba Reservoir were based on an average flow of 262 cfs with a TSS concentration of 17 mg/L.
?? bank erosion rate of 0.2 feet/year and average bank height of 6 feet
?? 76 stream miles between Yuba Dam and DMAD Reservoir
?? soil loss parameters described in Section 4.2.4
?? A portion of loads from each category are not transported all the way downstream to Lynndyl due to irrigation diversions.

Table 5-29. Summary of the sources of TSS loading in the Sevier River from DMAD Reservoir to the Yuba Dam.

Source Category	Load (kg/yr)	Percent
Land Erosion/Natural Geology	9,893,200	50%
Streambank Erosion	7,840,540	40%
Upstream	1,971,160	10%
Existing Load	**19,704,900**	**100%**

The TSS TMDL for this segment of the Sevier River is summarized in Table 5-30. Load reductions from the 90th to 100th flow percentile are not included due to the difficulty of achieving standards during these flood conditions. In essence, the 10 percent exceedances of water quality samples that the state allows are allocated to these flood conditions. Approximately a 7 percent reduction in loads is needed to meet the loading capacity.

Table 5-30. Summary of the TSS TMDL for the Sevier River from DMAD Reservoir to Yuba Dam.

Expressed as Interim Water Quality Targets

- ?? Documented improvement in health of macroinvertebrate communities
- ?? 90 mg/L instream TSS target
- ?? Documented improved riparian habitat conditions as measured using an appropriate habitat scoring methodology

Expressed as Loads

Existing Load (kg/yr)	Loading Capacity (kg/yr)	WLA (kg/yr)	LA (kg/yr)	MOS (kg/yr)	Reduction (kg/yr)
19,704,900	19,330,470	0	18,363,950	966,520	1,340,950

BMPs in this segment should focus on those that will serve to improve habitat conditions (and also further reduce sediment loadings; see Table 5-31). A number of possible combinations of the above BMPs could result in meeting the targeted load reductions. Table 5-32 below provides details for only one of these possible combinations. The locally led Sevier River Steering and Technical Advisory Committee will provide guidance and direction for implementation activities needed to achieve the necessary load reductions. The approaches outlined in Table 5-32 are subject to change based on local input.

Table 5-31. Best management practices recommended for the Sevier River TSS TMDL between DMAD Reservoir and Yuba Dam.

Practice Number	Practice Name	Intensity Level	Time frame for Load Reduction	Maintenance
210	Exotic Removal	Active	Immediate	Medium
260	Pole/Post Planting	Active	Months – Two Years	Low
221	Seeding	Active	Months – Two Years	Low

Table 5-32. Estimated impact of one potential set of best management practices for the Sevier River TSS TMDL between DMAD Reservoir and Yuba Dam.

Practice Number	Practice Name	Extent of Practice	Estimated Per Unit Load Reduction (kg/yr)	Resulting Load Reduction (kg/yr)
221	Seeding	Seed 10,000 acres to convert pasture lands and barren lands to grasslands	70 kg/yr/acre reduction in TSS resulting from conversion of poorly vegetated lands to grasslands[1]	700,000
260	Pole/Post Planting	Re-establish vegetation along 5 miles of most severely eroding streambanks	154,750 kg/yr reduction in TSS for every 1 mile of stabilized streambanks[2]	773,750
			Total Load Reduction	**1,473,750**

[1]Estimated load reduction based on lower USLE C-factors associated with grasslands compared to poorly vegetated lands.
[2]Estimated load reduction based on reducing near bank stress from moderate-high (0.25 feet/year) to low (0.1 feet/year).

5.4.3 DMAD Reservoir to U-132 crossing: Total Dissolved Solids

Recent TDS data are available at 2 stations for the Sevier River between the DMAD reservoir and the U-132 crossing (Table 5-33). Fifteen percent of the samples taken between 1996 and 2002 violated the 1,200 mg/L standard. Station 494210 is located along the Sevier River 1.5 miles south of Lynndyl and has the most TDS observations in this segment of the river. Values at this station are typically greatest in February and are slightly below or near the standard the rest of the year (Figure 5-22). There does not appear to be any long-term trend in TDS over the period of record (Figure 5-23).

Table 5-33. Available TDS data for the Sevier River between the DMAD Reservoir and U-132 crossing.

Station	No. of Samples	Average	Min	Max	CV*	Min Date	Max Date
494210 (south of Lynndyl)	189	1,179	224	3,288	34%	10/12/76	7/30/02
10224000 (USGS gage near Lynndyl)	417	1,571	275	5,980	46%	10/1/52	8/16/94

*CV = coefficient of variation (standard deviation divided by the mean).

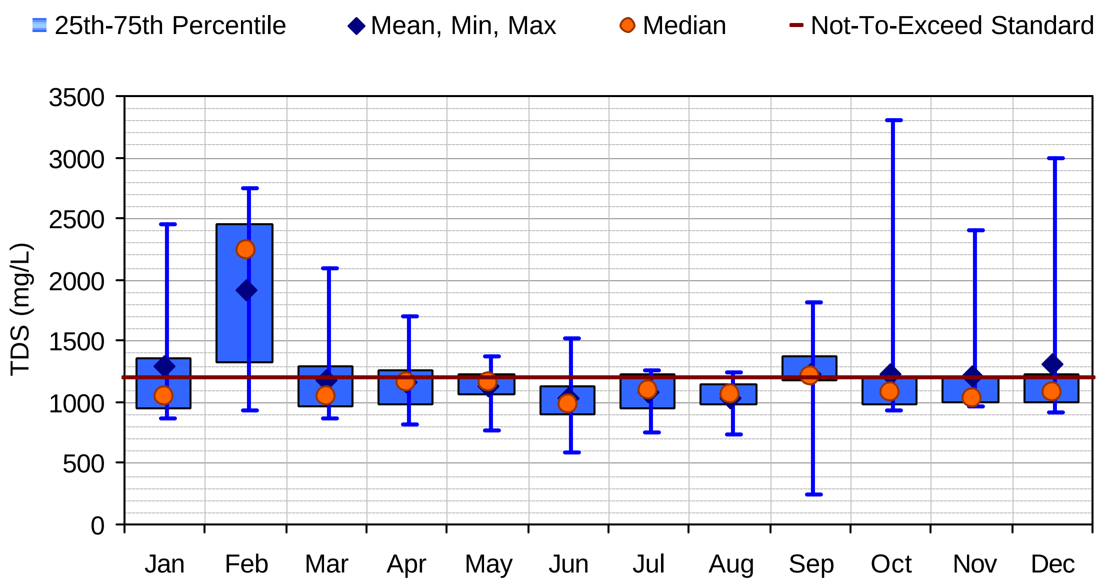

Figure 5-22. Monthly TDS concentrations at station 494210 (south of Lynndyl).

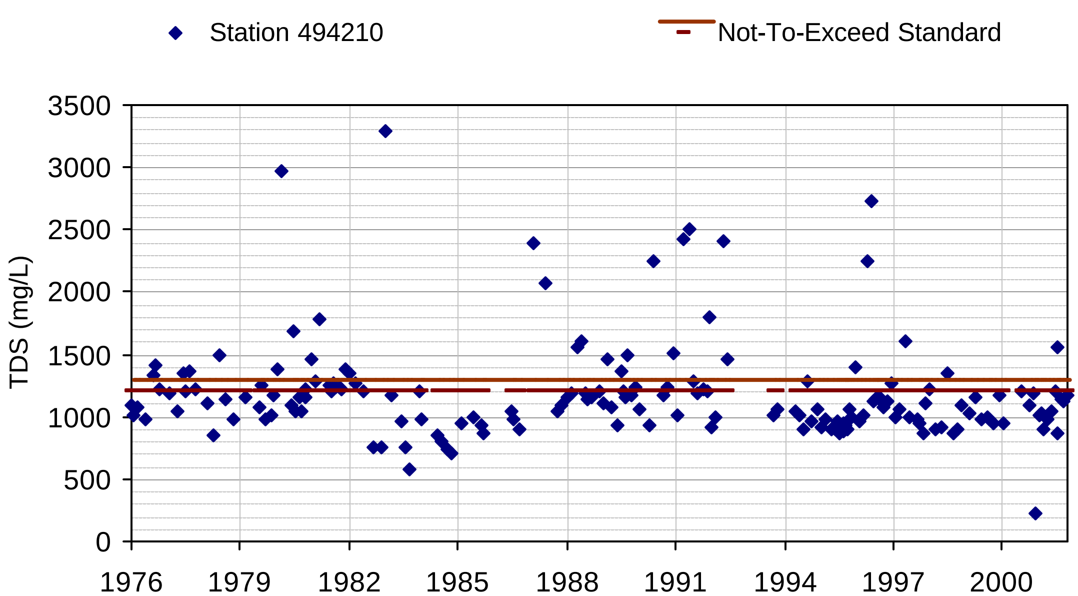

Figure 5-23. All TDS data for Station 494210 (south of Lynndyl).

The results of the load duration analysis are presented in Figure 5-24 and Table 5-34. They indicate that TDS loads above the loading capacity mainly occur during low flows. The very highest flow frequencies also showed existing loads slightly greater than the loading capacity. Note that water quality is generally below the standard during the critical irrigation months (April to October).

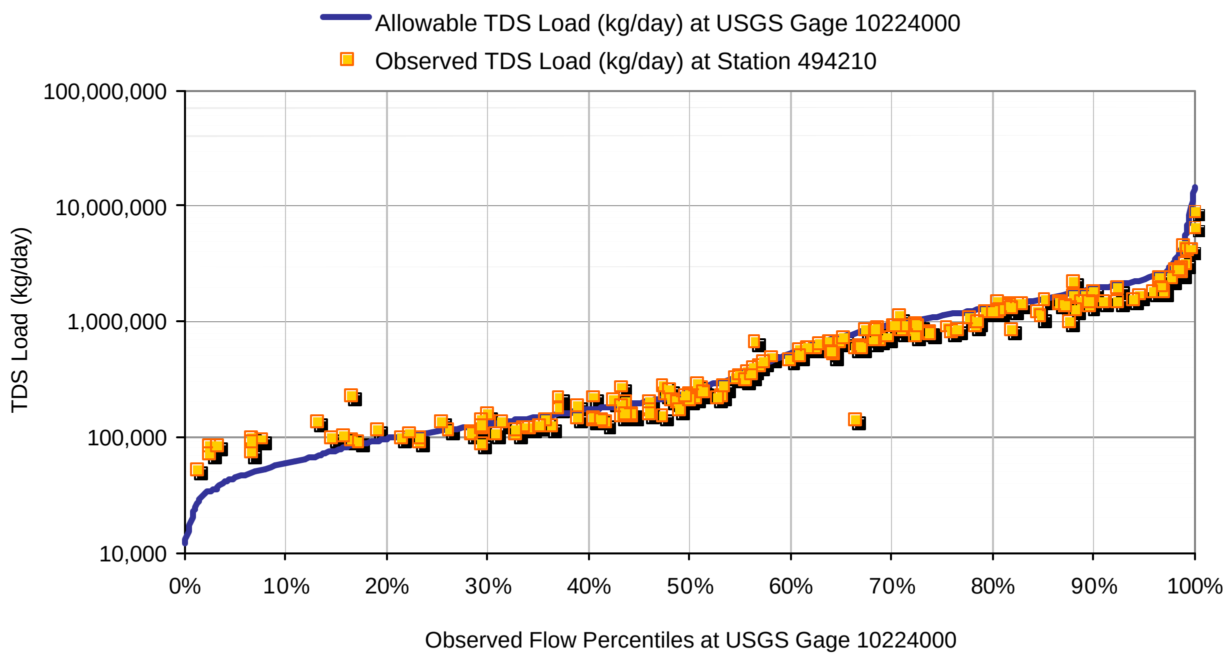

Figure 5-24. TDS Load Duration Curve at Station 494210.

Table 5-34. TDS observed and allowable loading at station 494210.

Flow Percentile Ranges	181-Sample Distribution	Median Observed Flow (cfs)	Observed Load (kg/day)	Observed Concentration (mg/L)	Allowable Load (kg/day)	Estimated Reduction (%)	Estimated Reduction (kg/day)
0-10	8	15	87,093	2,373	44,038	49.40%	43,055
10-20	7	26	103,167	1,622	76,333	26.00%	26,834
20-30	13	38	112,210	1,207	111,564	0.60%	646
30-40	14	50	132,834	1,086	146,795	0.00%	0
40-50	29	67	180,851	1,103	196,705	0.00%	0
50-60	20	118	328,798	1,139	346,435	0.00%	0
60-70	21	249	648,049	1,064	731,037	0.00%	0
70-80	19	380	932,101	1,003	1,115,638	0.00%	0
80-90	27	535	1,440,661	1,101	1,570,702	0.00%	0
90-100	22	787	2,430,756	1,262	2,310,546	4.90%	120,210

Sources of TDS in this segment of the Sevier River include upstream loads, irrigation return flows, and land and streambank erosion. Table 5-35 summarizes the relative magnitude of each of these source categories. The key assumptions used to derive these estimated loads are as follows:

?? 20,000 acres of irrigated lands
?? 36 inches of water applied per year
?? 70 percent efficiency for irrigation
?? 50 percent of unconsumed irrigated water returned to the river
?? average flow of 262 cfs from Yuba Reservoir with a TDS concentration of 894 mg/L.

Table 5-35. Summary of the sources of TDS loading in the Sevier River from DMAD Reservoir to the U-132 Crossing.

Source Category	Load (kg/yr)	Percent
Upstream	209,041,180	90%
Land Erosion/Natural Geology	15,455,230	7%
Irrigation Return Flows	8,357,060	3%
Existing Load (kg/yr)	**232,853,470**	**100.00%**

The TDS TMDL for this segment of the Sevier River is summarized in Table 5-36. Approximately an 8 percent reduction in existing loads is needed to meet water quality standards.

Table 5-36. Summary of the TDS TMDL for the Sevier River from DMAD Reservoir to the U-132 Crossing.

Expressed as Endpoints					
?? 1,200 mg/L TDS instream target					
Expressed as Loads					
Existing Load (kg/yr)	**Loading Capacity (kg/yr)**	**WLA (kg/yr)**	**LA (kg/yr)**	**MOS (kg/yr)**	**Reduction (kg/yr)**
232,853,470	225,811,300	0	214,520,730	11,290,570	18,332,740

Table 5-37 lists one potential set of best management practices to achieve the necessary TDS load reductions for this segment of the Sevier River. Because streamflows in this segment are significantly impacted by discharge from Yuba Reservoir, a relatively small reduction in the average concentration of the discharge will have a significant effect on downstream concentrations. It is conceivable that this reduction will occur as a result of TMDL implementation activities taken upstream of Yuba Reservoir, although a detailed analysis of the fate and transport of pollutants in the reservoir was outside the scope of the current study.

Table 5-37. Estimated impact of one potential set of best management practices for the Sevier River TDS TMDL from DMAD Reservoir to the U-132 Crossing.

Practice Number	Practice Name	Extent of Practice	Estimated Per Unit Load Reduction (kg/yr)	Resulting Load Reduction (kg/yr)
440	Irrigation Land Leveling	Utilize land leveling techniques for 500 acres, thus increasing efficiencies from 70 percent to 80 percent	140 kg/yr/acre reduction in TDS moving from 70 percent efficiency to 80 percent	70,000
N/A	N/A	Reduce average concentration in discharge from Yuba Reservoir from 894 mg/L to 850 mg/L	N/A	10,288,380
210	Exotic Removal	Eliminate 25 percent of salt cedar trees	NA[1]	NA
			Total Load Reduction	**10,323,380**

[1]Few data are available with which to quantify the load reduction in TDS that would result from replacing salt cedar trees with native vegetation. However, there is widespread agreement that removing salt cedar should result in improved water quality, both due to reduced TDS loads and decreased evapotranspiration rates.

5.5 Sevier River from Gunnison Bend Reservoir to DMAD Reservoir

The Sevier River from the Gunnison Bend Reservoir to the DMAD Reservoir is listed for total dissolved solids, sediment, and habitat alteration. The habitat alteration listing is closely related to the sediment listing because both impairments are associated with flow alterations and streambank de-stabilization. Dense populations of tamarisk trees in this segment have also affected habitat conditions. Figure 5-25 displays land uses within the defined buffer for this segment of the Sevier River. The dominant land cover/land use is salt desert (54 percent), alfalfa (20 percent), and grain (7 percent).

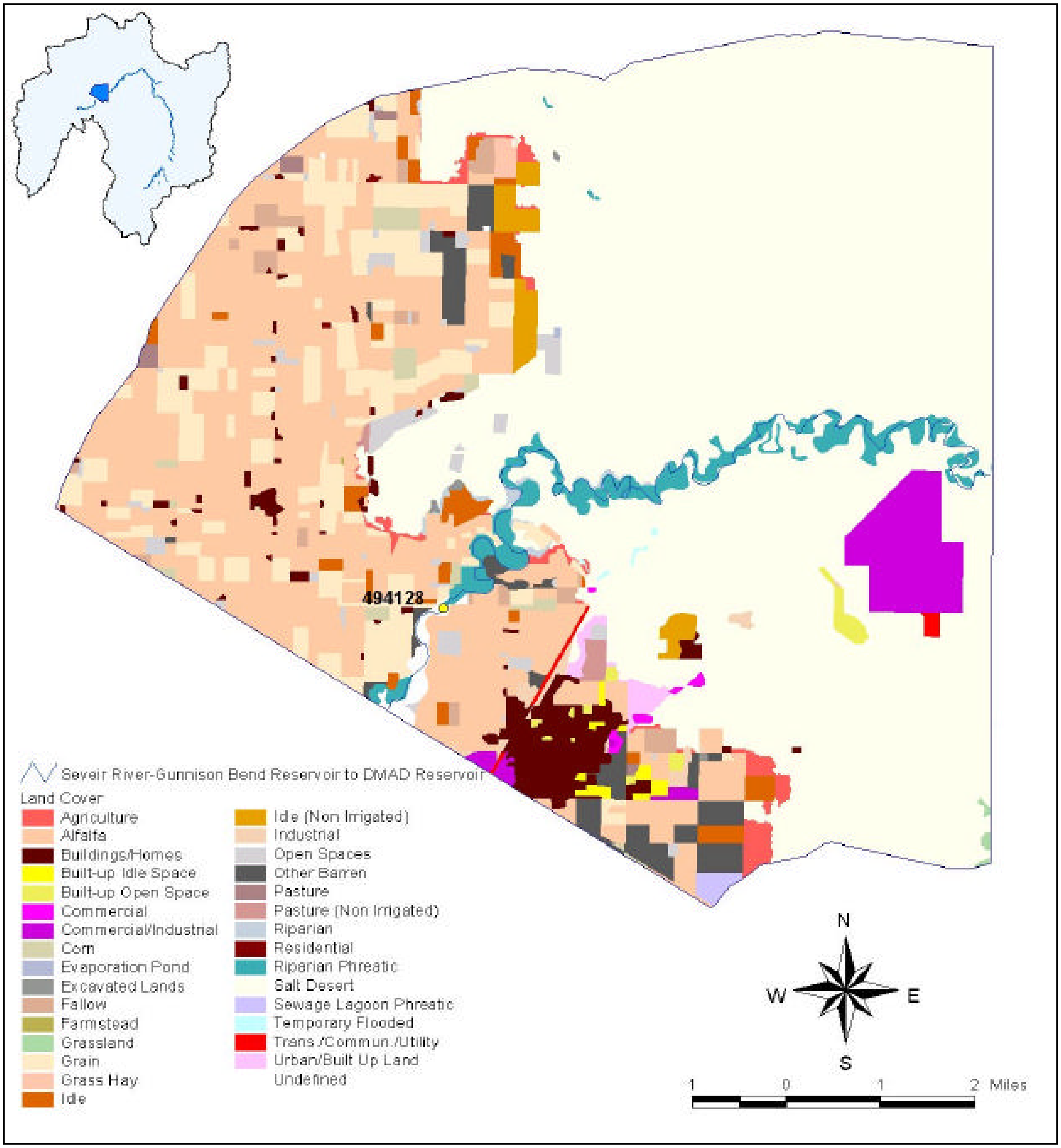

Figure 5-25. Land use and land cover within the buffer zone along the Sevier River – Gunnison Bend Reservoir to DMAD Reservoir.

5.5.1 Gunnison Bend Reservoir to DMAD Reservoir: TDS

Recent TDS data are available at only one station on the Sevier River between the Gunnison Bend Reservoir and the DMAD Reservoir (Table 5-38). Station 494128 is located on the Sevier River west of Delta at the CR53 crossing and twenty-five percent of the samples taken at this station between 1996 and 2002 exceeded the 1,200 mg/L standard. Values are typically higher in the fall and winter and lower in the spring and summer (Figure 5-26). This likely is due to the regulation of the reservoir and the amount of water in the channel (i.e., winter storage resulting in low flows and summer releases resulting in higher flows). There does not appear to be a long-term trend in TDS over the period of record (Figure 5-27).

Table 5-38. Available TDS data for the Sevier River between the Gunnison Bend Reservoir and the DMAD Reservoir.

Station	No. of Samples	Average	Min	Max	CV*	Min Date	Max Date
494128 (at CR53 crossing)	162	1,257	246	2,308	27%	8/10/76	6/11/02

*CV = coefficient of variation (standard deviation divided by the mean).

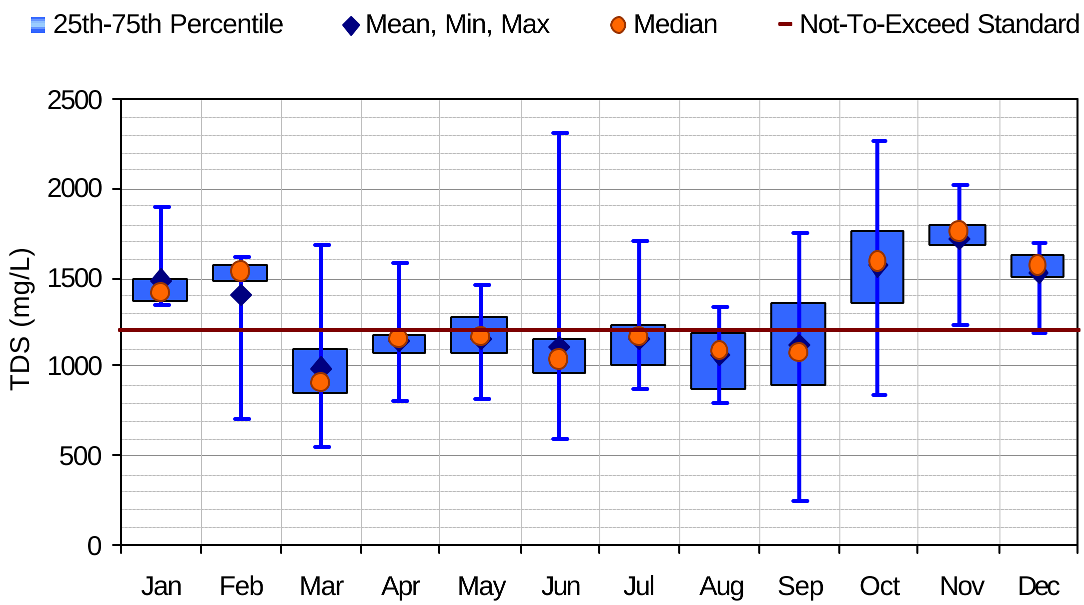

Figure 5-26. Monthly TDS concentrations at station 494128 (at CR53 crossing). Data cover the period August 10, 1976 to June 11, 2002.

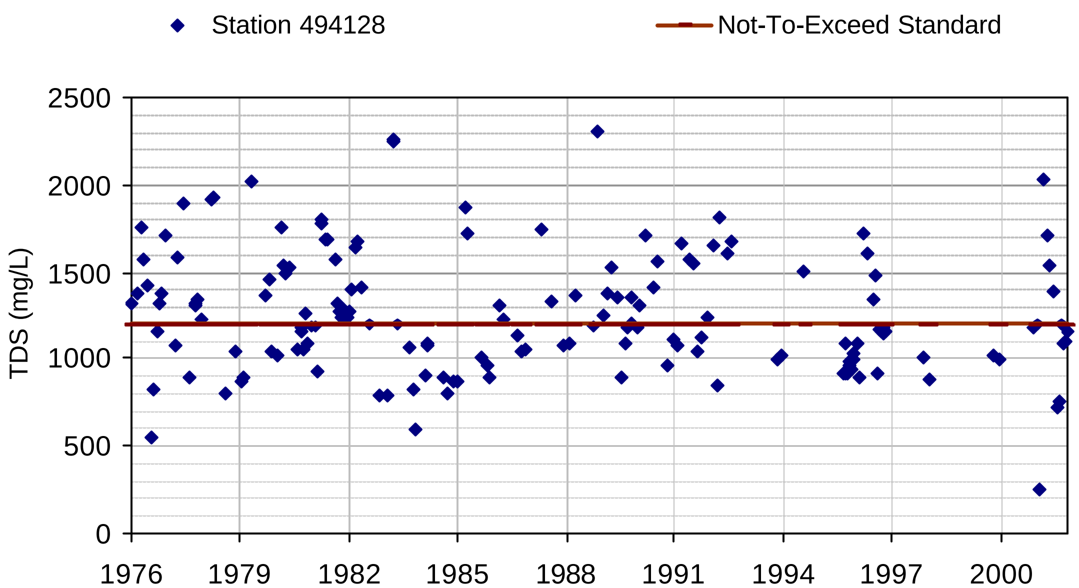

Figure 5-27. All TDS data for station 494128 (CR53 crossing).

The results of the load duration analysis are presented in Table 5-39 and Figure 5-28. They indicate that roughly one-third of the flows have a median load above the loading capacity limit. Additionally, the greatest risk of exceeding the TDS standard of 1,200 mg/l occurs during low to medium flows. At these flow regimes, the TDS standard is exceeded approximately 20 percent of the time. The data suggest the need for reductions of TDS during lower flow regimes for this segment of the Sevier River. The greatest load reductions are needed for the 40^{th} to 50^{th} percentile flow group.

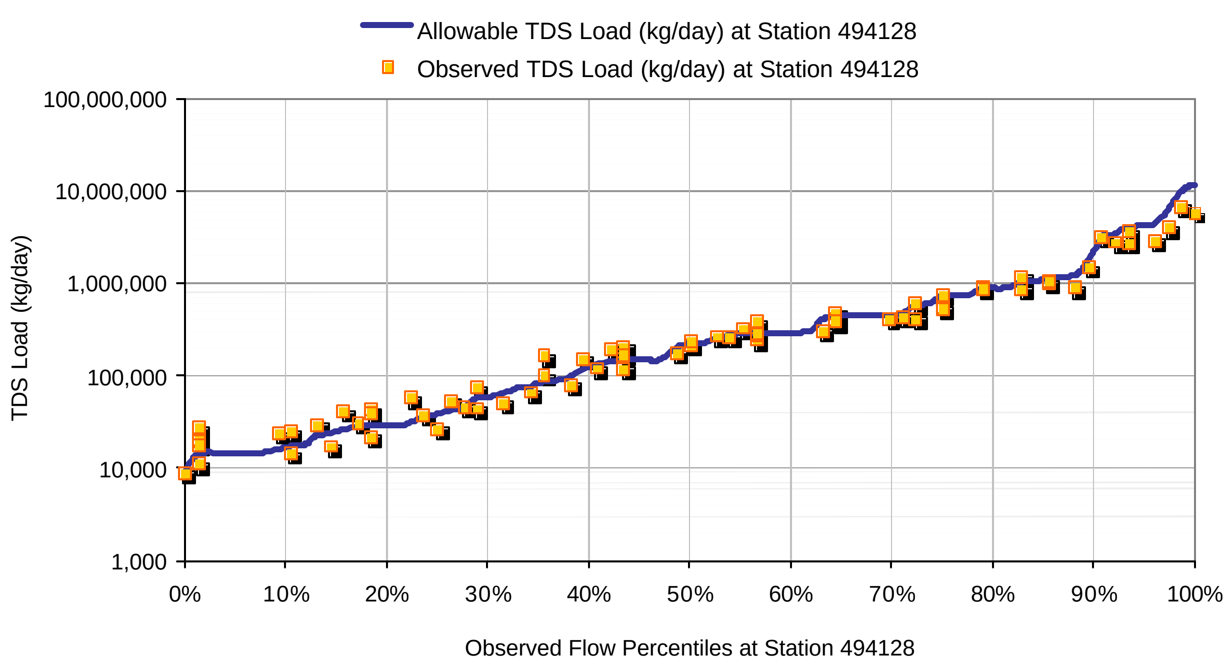

Figure 5-28. TDS Load Duration Curve at Station 494128 on the Sevier River between Gunnison Bend Reservoir and DMAD Reservoir.

Table 5-39. Observed and allowable TDS load for station 494128.

Flow Percentile Ranges	76-Sample Distribution	Median Observed Flow (cfs)	Observed Load (kg/day)	Observed Concentration (mg/L)	Allowable Load (kg/day)	Estimated Reduction (%)	Estimated Reduction (kg/day)
0-10	8	5	20,307	1,660	14,679	27.70%	5,628
10-20	6	8.4	27,268	1,327	24,661	9.60%	2,607
20-30	8	13	41,885	1,317	38,167	8.90%	3,718
30-40	8	28.24	77,786	1,126	82,910	0.00%	0
40-50	7	50	178,796	1,462	146,795	17.90%	32,001
50-60	5	97.46	265,813	1,115	286,132	0.00%	0
60-70	11	150	385,580	1,051	440,384	0.00%	0
70-80	6	250	543,751	889	733,973	0.00%	0
80-90	9	380	945,357	1,017	1,115,638	0.00%	0
90-100	7	1,420.00	3,213,332	925	4,168,965	0.00%	0

Sources of TDS in this segment of the Sevier River include upstream loads, irrigation return flows, and land and streambank erosion. Table 5-40 summarizes the relative magnitude of each of these source categories. The key assumptions used to derive these estimated loads are as follows:

- 20,000 acres of irrigated crops
- 36 inches water applied
- High efficiency (80%) irrigation
- 25 percent of unconsumed irrigation water returns to the Sevier River
- Average annual flow of 56 cfs from DMAD Reservoir at 1,163 mg/L TDS

Table 5-40. Summary of the sources of TDS loading in the Sevier River from Gunnison Bend Reservoir to DMAD Reservoir.

Source Category	Load (kg/yr)	Percent
Land Erosion/Natural Geology	138,077,730	67%
Upstream	58,124,710	28%
Irrigation Return Flows	11,142,740	5%
Total	**207,345,180**	**100%**

The TDS TMDL for this segment of the Sevier River is summarized in Table 5-41. Only a 6 percent reduction is required to achieve the loading capacity.

Table 5-41. Summary of the TDS TMDL for the Sevier River between the Gunnison Bend Reservoir and the DMAD Reservoir.

Expressed as Endpoints					
- 1,200 mg/L instream TDS target					
Existing Load (kg/yr)	**Loading Capacity (kg/yr)**	**WLA (kg/yr)**	**LA (kg/yr)**	**MOS (kg/yr)**	**Reduction (kg/yr)**
207,345,180	205,835,330	0	195,543,560	10,291,770	11,801,620

Load reductions in this segment of the Sevier River might benefit if the TDS allocations identified for upstream segments are met. BMPs in this segment should therefore focus on streambank restoration to reduce sediment loads and also improve habitat conditions (Table 5-42). A number of possible combinations of the above BMPs could result in meeting the targeted load reductions. Table 5-43 below provides details for only one of these possible combinations. This combination relies heavily on reductions in the average concentration of TDS discharged from DMAD Reservoir because of the significant impact discharges from the reservoir have on downstream water quality. It is conceivable that the necessary reduction will occur as a result of upstream load reductions to DMAD Reservoir, although a detailed analysis of the fate and transport of pollutants in the reservoir was outside the scope of the current study. The locally led Sevier River Steering and Technical Advisory Committee will provide guidance and direction for implementation activities needed to achieve the necessary load reductions. Therefore the approaches outlined in Table 5-43 are subject to change based on local input.

Table 5-42. Best management practices recommended for the Sevier River between the Gunnison Bend Reservoir and the DMAD Reservoir.

Practice Number	Practice Name	Intensity Level	Time frame for Load Reduction	Maintenance
260	Pole/Post Planting	Active	Months – Two Years	Low
210	Exotic Removal	Active	Immediate	Medium

Table 5-43. Estimated impact of one potential set of best management practices for the Sevier River TDS TMDL between Gunnison Bend Reservoir and the DMAD Reservoir.

Practice Number	Practice Name	Extent of Practice	Estimated Per Unit Load Reduction (kg/yr)	Resulting Load Reduction (kg/yr)
221	Seeding	Seed 15,000 acres to convert poorly vegetated pasture lands and barren lands to grasslands	550 kg/yr/acre reduction in TDS resulting from conversion of poorly vegetated lands to grasslands	8,250,000
N/A	N/A	Reduce average concentration in discharge from DMAD Reservoir from 1,163 mg/L to 1,100 mg/L	N/A	3,148,630
210	Exotic Removal	Eliminate 100 acres of salt cedar between Gunnison Bend Reservoir and DMAD Reservoir	NA[1]	NA
			Total Load Reduction	**11,398,630**

[1]Few data are available with which to quantify the load reduction in TDS that would result from replacing salt cedar trees with native vegetation. However, there is widespread agreement that removing salt cedar should result in improved water quality, both due to reduced TDS loads and decreased evapotranspiration rates.

5.5.2 Gunnison Bend Reservoir to DMAD Reservoir: TSS TMDL

Recent TSS data are available at only one station on the Sevier River between the Gunnison Bend Reservoir and the DMAD Reservoir (Table 5-44). Ten percent of the samples taken between 1996 and 2002 exceeded the interim water quality target of 90 mg/L. Values are typically least in the late fall and winter months and highest from April through August (Figure 5-29). There does not appear to be a long-term trend over the period of record (Figure 5-30).

Table 5-44. Available TSS data for the Sevier River between the Gunnison Bend Reservoir and the DMAD Reservoir.

Station	No. of Samples	Average	Min	Max	CV*	Min Date	Max Date
494128	158	69	0	747	125%	6/1/76	6/11/02

*CV = coefficient of variation (standard deviation divided by the mean).

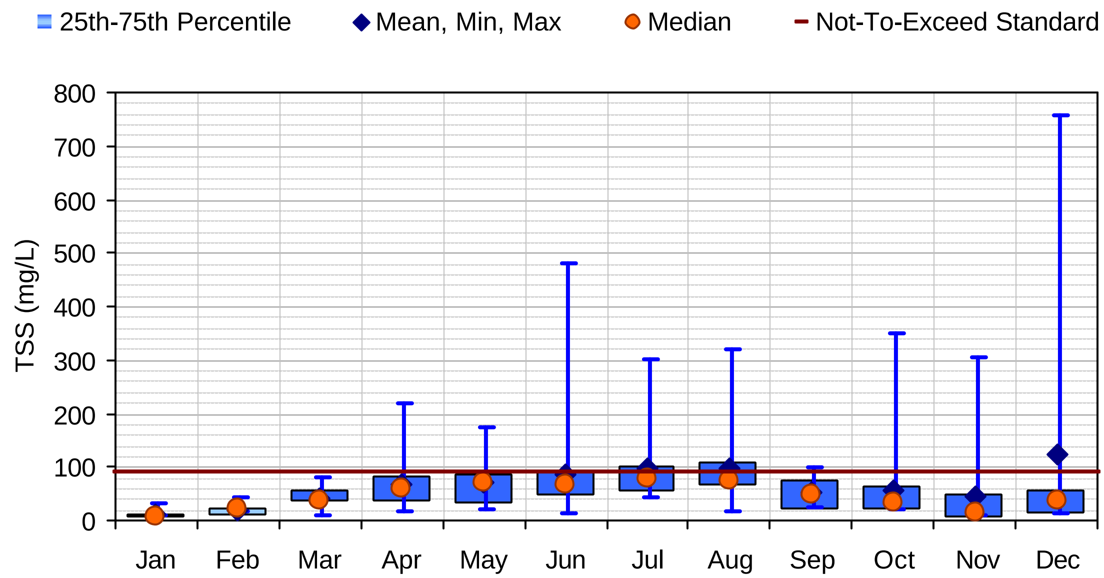

Figure 5-29. Monthly TSS data for station 494128. Data cover the period June 1, 1976 to June 11, 2002.

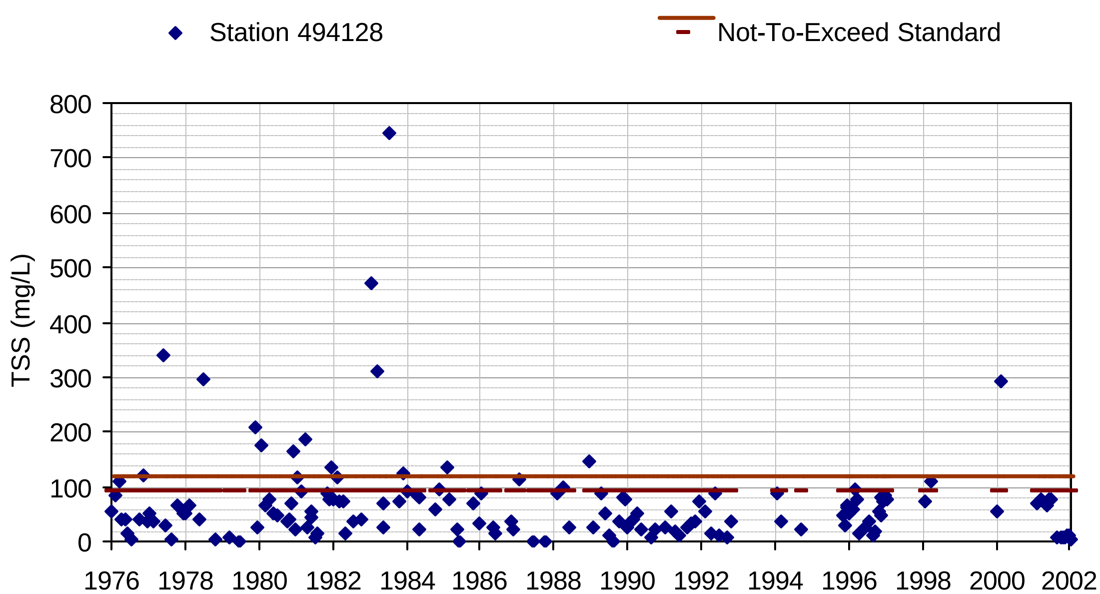

Figure 5-30. All TSS data for Station 494128.

The results of the load duration analysis for the Sevier River from Gunnison Bend Reservoir to DMAD Reservoir are displayed in Figure 5-31 and Table 5-45. They show that exceedances of the 90 mg/l target are associated with higher flows. These higher flows have a median load above the loading capacity limit, indicating the need for reductions of TSS during wet weather flows for this segment of the Sevier River. The greatest load reductions are needed for the 80^{th} to 90^{th} percentile flow group.

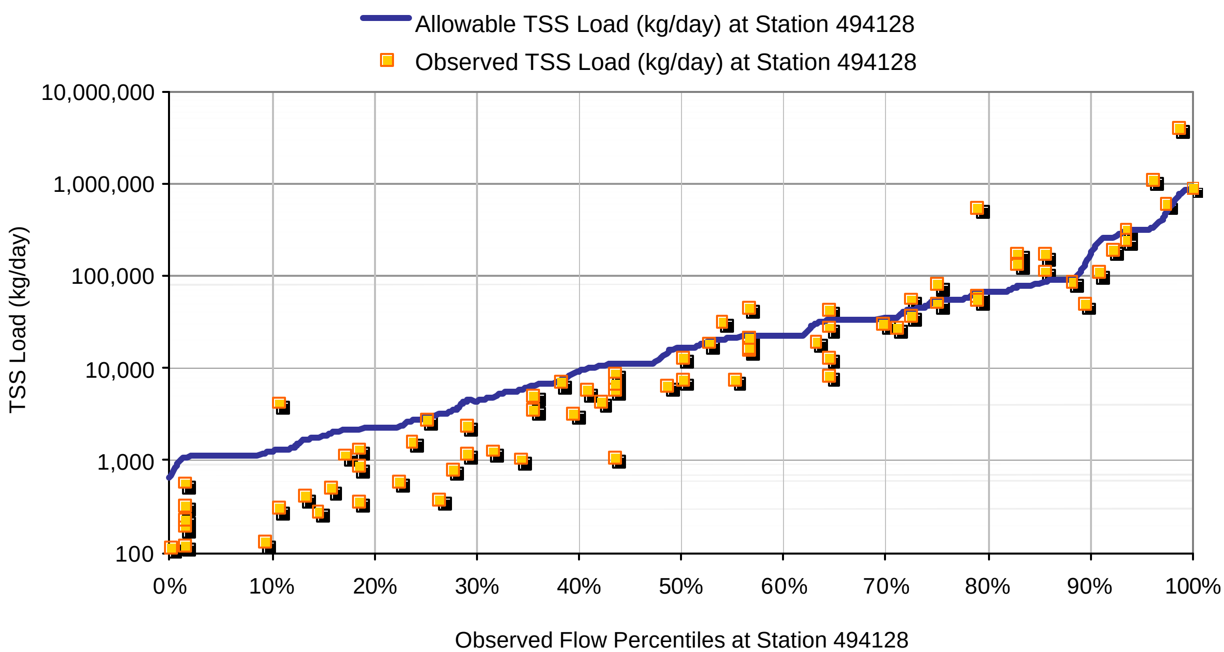

Figure 5-31. TSS load duration curve at Station 494128 on the Sevier River between Gunnison Bend Reservoir and DMAD Reservoir.

Table 5-45. Observed and allowable TSS loading for Station 494128.

Flow Percentile Ranges	75-Sample Distribution	Median Observed Flow (cfs)	Observed Load (kg/day)	Observed Concentration (mg/L)	Allowable Load (kg/day)	Estimated Reduction (%)	Estimated Reduction (kg/day)
0-10	7	5	196	16	1,101	0.00%	0
10-20	6	8	460	22	1,850	0.00%	0
20-30	8	13	844	27	2,862	0.00%	0
30-40	8	28	2,887	42	6,218	0.00%	0
40-50	7	50	5,994	49	11,010	0.00%	0
50-60	5	97	13,212	55	21,460	0.00%	0
60-70	11	150	21,285	58	33,029	0.00%	0
70-80	6	250	54,620	89	55,048	0.00%	0
80-90	9	380	115,478	124	83,673	27.50%	31,805
90-100	7	1,420	328,820	95	312,672	4.90%	16,148

Sources of TSS in this segment of the Sevier River include upstream loads, land erosion, and streambank erosion. Table 5-46 summarizes the relative magnitude of each of these source categories. Upstream loads were based on an average flow of 262 cfs from Yuba Reservoir with a TSS concentration of 17 mg/L.

Table 5-46. Summary of the sources of TSS loading in the Sevier River from Gunnison Bend Reservoir to DMAD Reservoir.

Source Category	Load (kg/yr)	Percent
Land Erosion/Natural Geology	14,252,330	72%
Streambank Erosion	3,713,940	19%
Upstream	1,699,260	9%
Total	**19,665,530**	100%

The TSS TMDL for this segment of the Sevier River is summarized in Table 5-47.

Table 5-47. Summary of the TSS TMDL for the Sevier River from Gunnison Bend Reservoir to DMAD Reservoir.

Existing Load (kg/yr)	Loading Capacity (kg/yr)	WLA (kg/yr)	LA (kg/yr)	MOS (kg/yr)	Reduction (kg/yr)
Expressed as Interim Water Quality Targets					
?? 90 mg/L instream TSS target			?? Documented improved riparian habitat conditions as measured using an appropriate habitat scoring methodology		
Expressed as Loads					
19,665,530	19,329,380	0	18,362,910	966,470	1,302,620

Table 5-48 identifies a number of potential BMPs to achieve the necessary load reductions. A number of possible combinations of the above BMPs could result in meeting the targeted load reductions. Table 5-49 below provides details for only one of these possible combinations. The locally led Sevier River Steering and Technical Advisory Committee will provide guidance and direction for implementation activities needed to achieve the necessary load reductions. Therefore the approaches outlined in Table 5-49 are subject to change based on local input.

Table 5-48. Best management practices recommended for the Sevier River TSS TMDL between Gunnison Bend Reservoir and DMAD Reservoir Dam.

Practice Number	Practice Name	Intensity Level	Time frame for Load Reduction	Maintenance
210	Exotic Removal	Active	Immediate	Medium
260	Pole/Post Planting	Active	Months – Two Years	Low

Table 5-49. Estimated impact of one potential set of best management practices for the Sevier River TSS TMDL between Gunnison Bend Reservoir and DMAD Reservoir Dam.

Practice Number	Practice Name	Extent of Practice	Estimated Per Unit Load Reduction (kg/yr)	Resulting Load Reduction (kg/yr)
221	Seeding	Seed 10,000 acres to convert pasture lands and barren lands to grasslands	70 kg/yr/acre reduction in TSS resulting from conversion of poorly vegetated lands to grasslands[1]	700,000
260	Pole/Post Planting	Re-establish vegetation along 5 miles of most severely eroding streambanks	154,750 kg/yr reduction in TSS for every 1 mile of stabilized streambanks[2]	773,750
			Total Load Reduction	**1,473,750**

[1]Estimated load reduction based on lower USLE C-factors associated with grasslands compared to poorly vegetated lands.
[2]Estimated load reduction based on reducing near bank stress from moderate-high (0.25 feet/year) to low (0.1 feet/year).

5.6 Sevier River from Crear Lake to Gunnison Bend Reservoir

The Sevier River between Crear Lake and Gunnison Bend Reservoir is listed for total dissolved solids. The dominant land use/land cover in this segment of the Sevier River is salt desert (51 percent), alfalfa (22 percent), and grain (6 percent) (Figure 5-32).

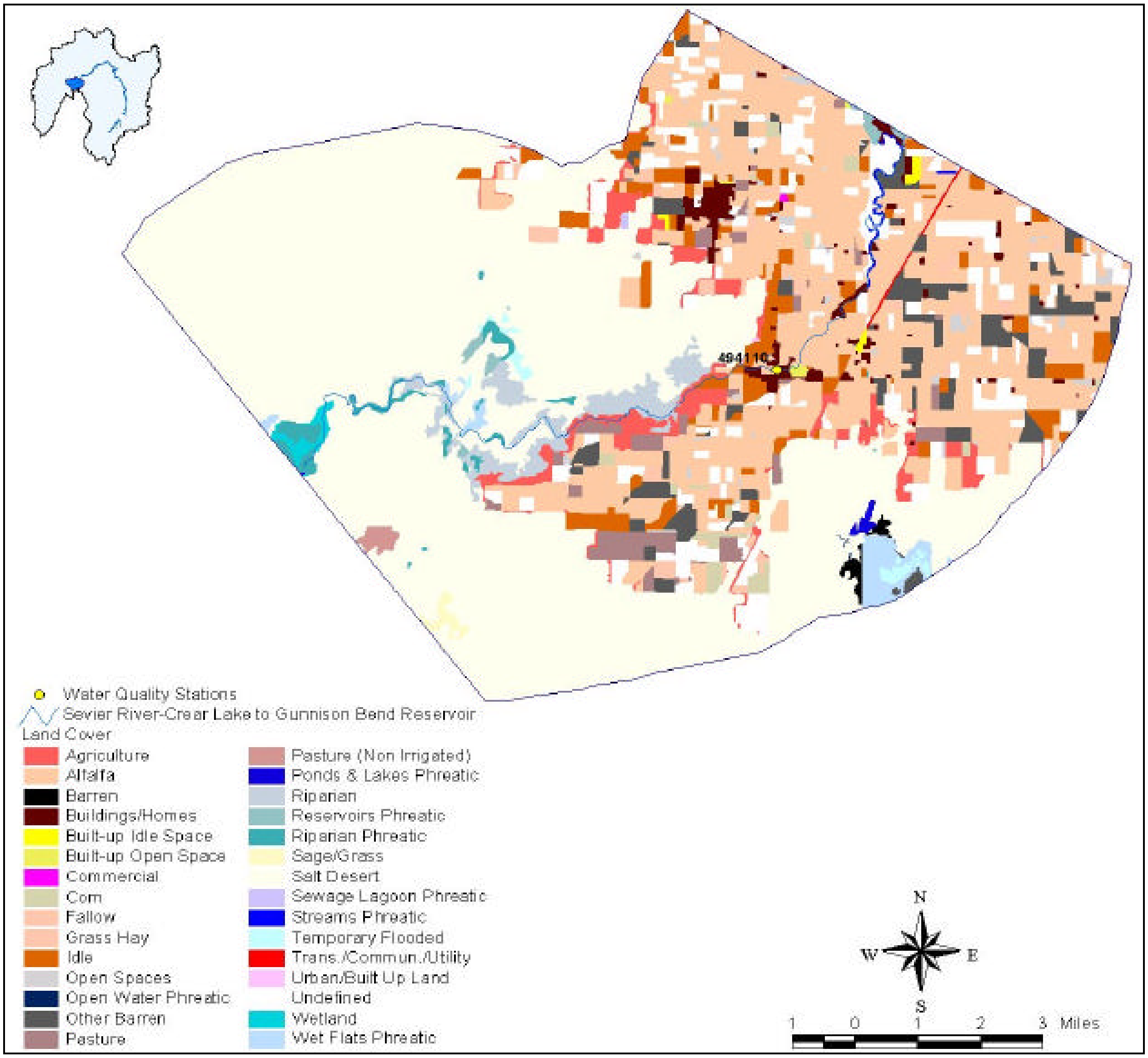

Figure 5-32. Land use and land cover within the buffer zone along the Sevier River – Crear Lake to Gunnison Bend Reservoir.

Recent TDS data are available at only one station on the Sevier River between Crear Lake and the Gunnison Bend Reservoir (Table 5-50). Station 494110 is located on the Sevier River at U-257 crossing in Deseret. Eighty-six percent of the samples taken at this station between 1996 and 2002 exceeded the water quality standard of 1,200 mg/L. Values at this station are typically highest in May, October, and November (Figure 5-33). There does not appear to be any long-term trend over the period of record (Figure 5-34).

Table 5-50. Available TDS data for the Sevier River between Crear Lake and Gunnison Bend Reservoir.

Station	No. of Samples	Average	Min	Max	CV*	Min Date	Max Date
494110 (U-257 crossing)	166	2,445	340	4,386	33%	5/19/80	6/11/02

*CV = coefficient of variation (standard deviation divided by the mean).

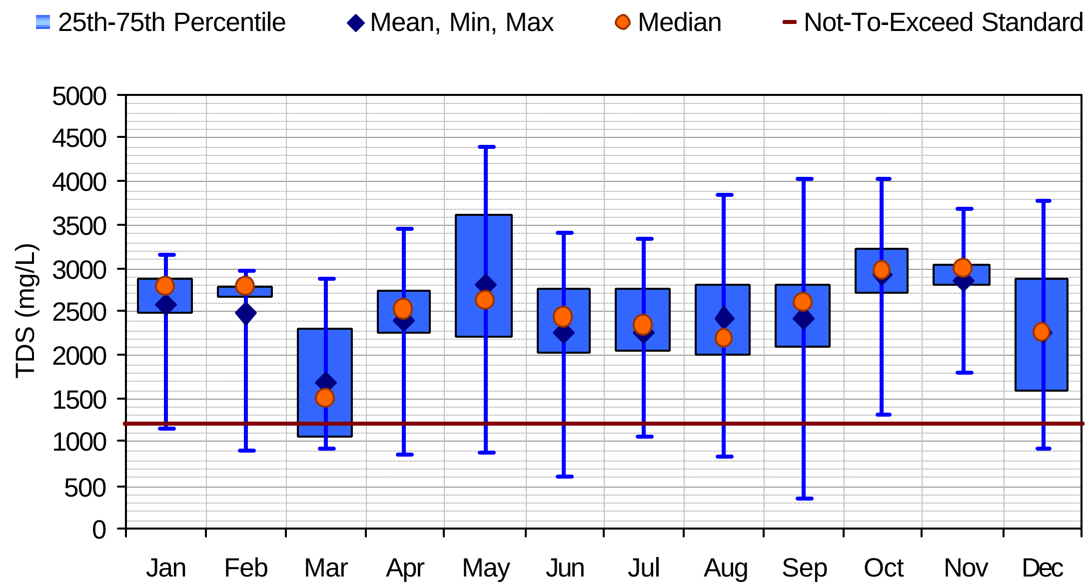

Figure 5-33. Monthly TDS concentrations at station 494110. Data cover the period May 19, 1980 to June 11, 2002.

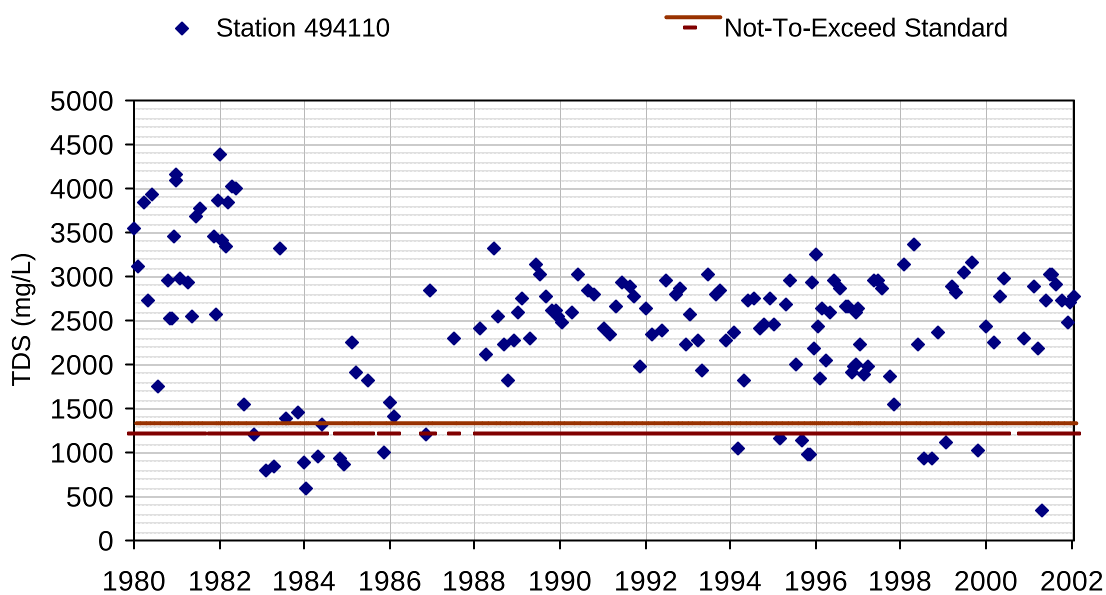

Figure 5-34. All TDS data at station 494110 on the Sevier River between Crear Lake and Gunnison Bend Reservoir.

The results of the load duration analysis are presented in Figure 5-33 and Table 5-51. Table 5-51 illustrates that most percentile groups have a median load almost twice the loading capacity, indicating the need for reductions of TDS at most flows for this segment of the Sevier River. Only at the highest flow are existing loads less than the loading capacity. The greatest load reductions are needed for the 80th to 90th percentile flow group.

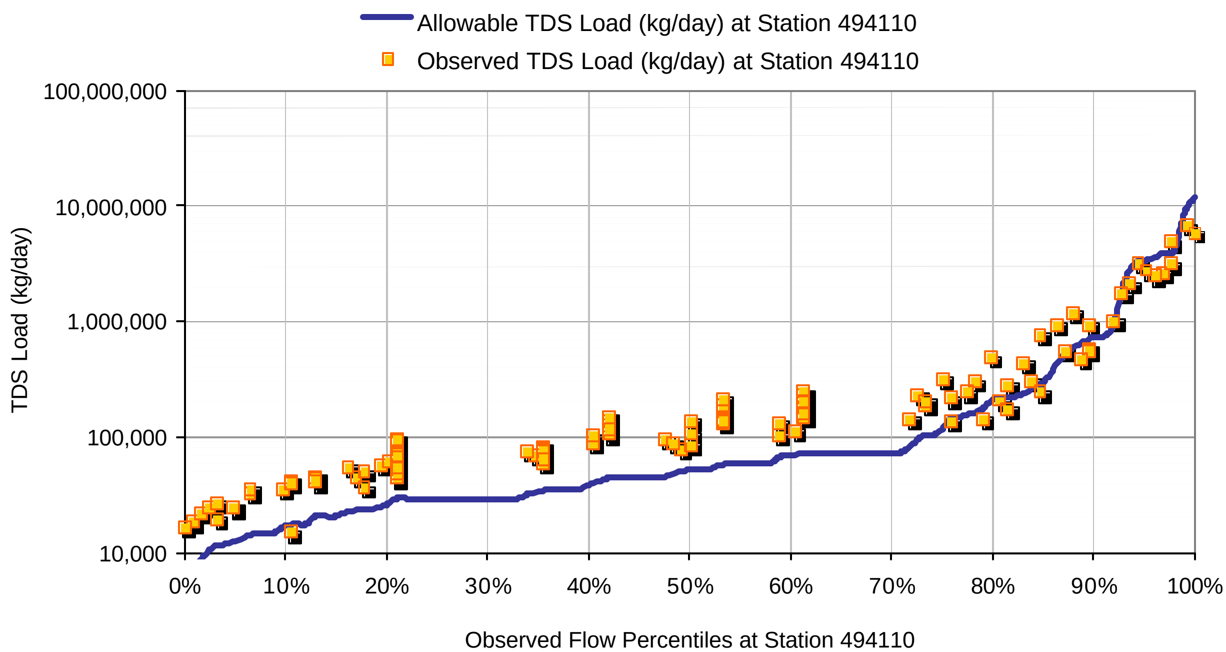

Figure 5-35. TDS Load Duration Curve at Station 494110 on the Sevier River between Crear Lake and Gunnison Bend.

Table 5-51. Observed and allowable TDS load for station 494110.

Flow Percentile Ranges	125-Sample Distribution	Median Observed Flow (cfs)	Observed Load (kg/day)	Observed Concentration (mg/L)	Allowable Load (kg/day)	Estimated Reduction (%)	Estimated Reduction (kg/day)
0-10	13	4.3	25,312	2,406	12,624	50.10%	12,688
10-20	12	7	43,109	2,517	20,551	52.30%	22,558
20-30	1	10	61,434	2,511	29,359	52.20%	32,075
30-40	24	11.4	70,713	2,535	33,469	52.70%	37,244
40-50	12	15	110,610	3,014	44,038	60.20%	66,572
50-60	13	20	137,498	2,810	58,718	57.30%	78,780
60-70	1	25	115,426	1,887	73,397	36.40%	42,029
70-80	24	40	186,013	1,901	117,436	36.90%	68,577
80-90	11	100	438,426	1,792	293,589	33.00%	144,837
90-100	13	1,140.00	2,513,122	901	3,346,915	0.00%	0

Sources of TDS in this segment of the Sevier River include upstream loads, irrigation return flows, and land erosion. Table 5-52 summarizes the relative magnitude of each of these source categories. The key assumptions used to derive these estimated loads are as follows:

- ?? 35,000 acres of irrigated crops
- ?? 36 inches water applied
- ?? High efficiency (80%)
- ?? 25 percent of unconsumed irrigation water is returned to the river
- ?? Increase of 1,000 mg/L TDS due to irrigation
- ?? Average annual flow of 50 cfs from Gunnison Reservoir at 2,168 mg/L TDS

Table 5-52. Summary of the sources of TDS loading in the Sevier River from Crear Lake to Gunnison Bend Reservoir.

Source Category	Load (kg/yr)	Percent
Upstream from Gunnison Bend Reservoir	78,091,020	62%
Land Erosion/Natural Geology	42,639,720	34%
Irrigation	4,874,950	4%
Total	**125,605,690**	**100%**

The TDS TMDL for this segment of the Sevier River is summarized in Table 5-53. Approximately a 19 percent reduction in loads is needed to meet the loading capacity.

Table 5-53. Summary of the TDS TMDL for the Sevier River from Crear Lake to Gunnison Bend Reservoir.

Expressed as Endpoints					
?? 1,200 mg/L instream TDS concentration					
Expressed as Loads					
Existing Load (kg/yr)	**Loading Capacity (kg/yr)**	**WLA (kg/yr)**	**LA (kg/yr)**	**MOS (kg/yr)**	**Reduction (kg/yr)**
125,605,690	106,706,510	0	101,371,180	5,335,330	24,234,510

Achieving the identified load reductions in this segment of the Sevier River will be very difficult if the concentration of discharges from Gunnison Bend Reservoir is not reduced. A number of possible additional BMPs could reduce loads in this segment of the river. Table 5-44 identifies several possible BMPs and Table 5-55 below provides details for only one of these possible combinations. Reductions in the concentration of TDS from Gunnison Bend Reservoir will be necessary because of the significant impact the reservoir has on downstream water quality. It is conceivable that this reduction will occur as a result of upstream load reductions, although a detailed analysis of the fate and transport of pollutants in the reservoir was outside the scope of the current study.

Table 5-54. Best management practices recommended for Sevier River from Crear Lake to Gunnison Bend Reservoir.

Practice Number	Practice Name	Intensity Level	Time frame for Load Reduction	Maintenance
260	Pole/Post Planting	Active	Months – Two Years	Low
210	Exotic Removal	Active	Immediate	Medium

Table 5-55. Estimated impact of one potential set of best management practices for the Sevier River TDS TMDL from Crear Lake to Gunnison Bend Reservoir.

Practice Number	Practice Name	Extent of Practice	Estimated Per Unit Load Reduction (kg/yr)	Resulting Load Reduction (kg/yr)
221	Seeding	Seed 10,000 acres to convert poorly vegetated pasture lands and barren lands to grasslands	550 kg/yr/acre reduction in TDS resulting from conversion of poorly vegetated lands to grasslands	5,500,000
N/A	N/A	Reduce average concentration in discharge from Gunnison Reservoir from 2,168 mg/L to 1,750 mg/L	N/A	18,652,598
210	Exotic Removal	Eliminate 100 acres of salt cedar	NA[1]	NA
			Total Load Reduction	**24,152,598**

5.7 Salina Creek (Confluence with the Sevier River to the USFS boundary)

Salina Creek between the confluence with the Sevier River and the USFS boundary is listed for total dissolved solids. The various land uses found within the buffered stream segment for Salina Creek are displayed in Figure 5-36. The dominant land uses/land cover are sage/grass (31 percent), pinyon/juniper (13 percent), and alfalfa (12 percent). Additionally, the lower-most stream segment is dominated by residential land uses.

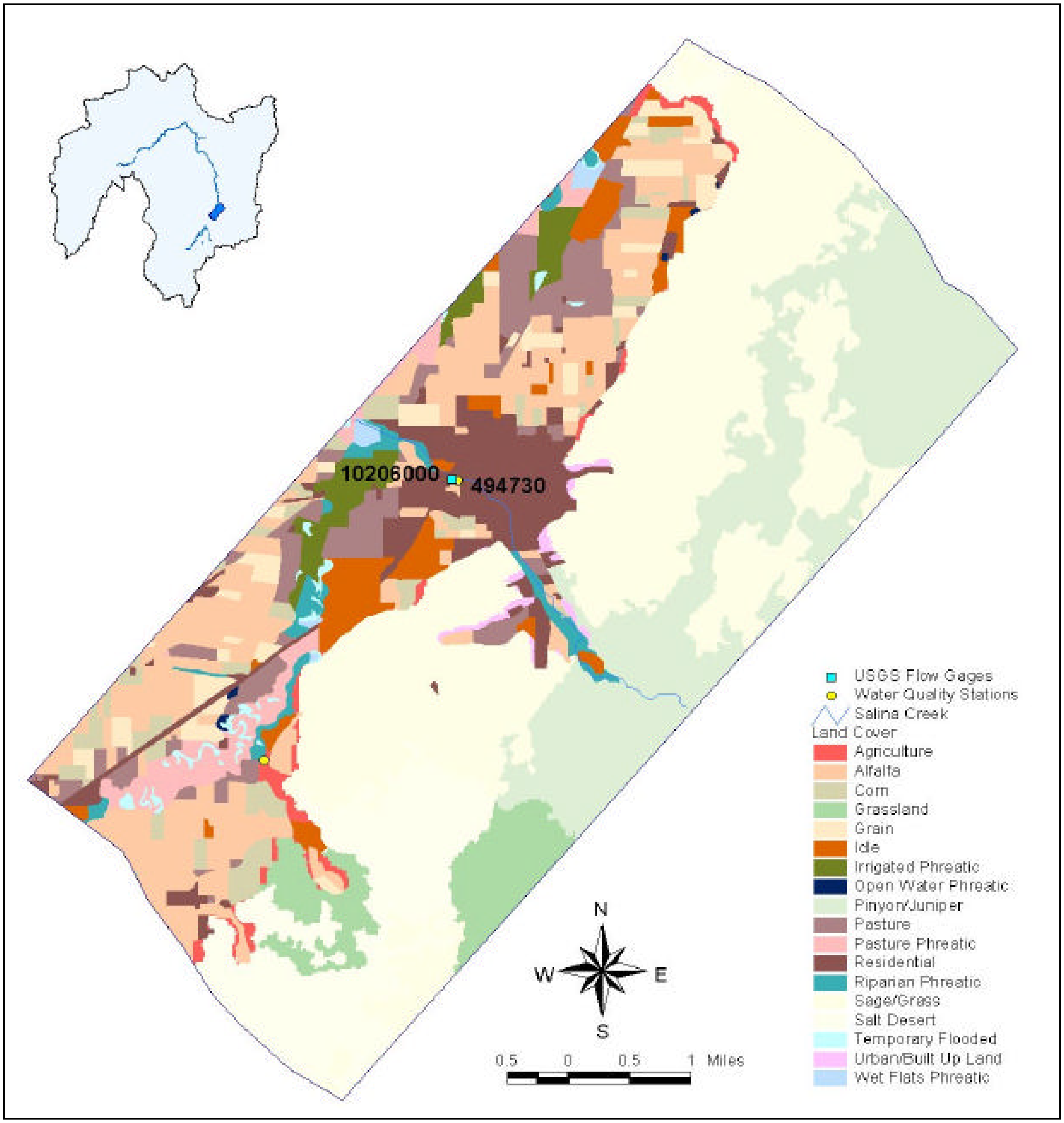

Figure 5-36. Land use and land cover within the buffer zone along Salina Creek.

5.7.1 Salina Creek: Total Dissolved Solids

Recent TDS data are available at only one station on Salina Creek between the confluence with the Sevier River and the USFS boundary (Table 5-56). Station 494730 is located along Salina Creek at the US-89 crossing. Thirty-seven percent of the samples taken at this station between 1996 and 2002 exceeded the 1,200 mg/L standard. Values at this station typically exceed the standard only in July, August, and September (Figure 5-37). Figure 5-38 indicates that more recent samples at this station are slightly greater than earlier periods.

Table 5-56. Summary of TDS data for stations on Salina Creek between the confluence with the Sevier River and the USFS boundary.

Station	No. of Samples	Average	Min	Max	CV*	Min Date	Max Date
494730 (US-89 crossing)	129	1027	242	5418	69%	7/16/75	6/20/02

*CV = coefficient of variation (standard deviation divided by the mean).

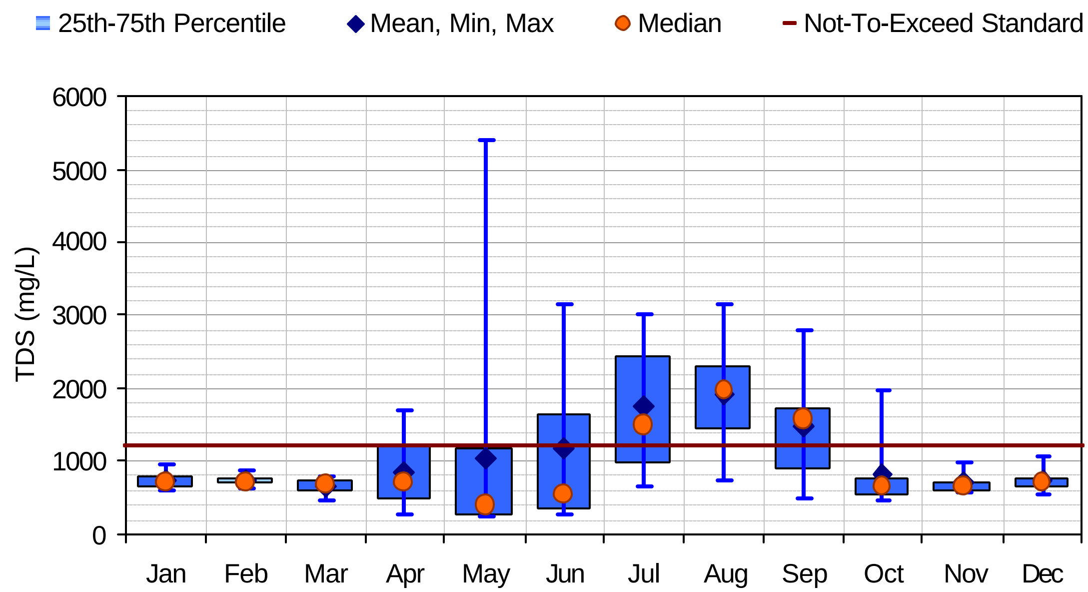

Figure 5-37. Monthly TDS concentrations for station 494730 (US-89 crossing). Data cover the period July 16, 1975 to June 30, 2002.

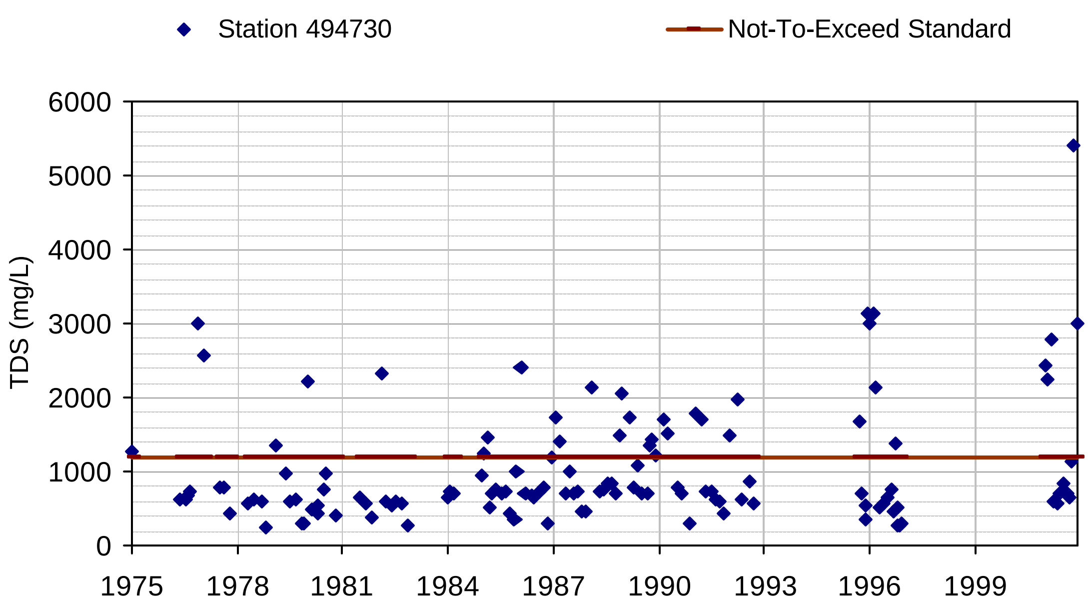

Figure 5-38. All TDS data for station 494730 (US-89 crossing) on Salina Creek.

The results of the load duration analysis are presented in Figure 5-39 and Table 5-57. Both the table and the figure indicate that existing loads only exceed the loading capacity during the lowest flow periods.

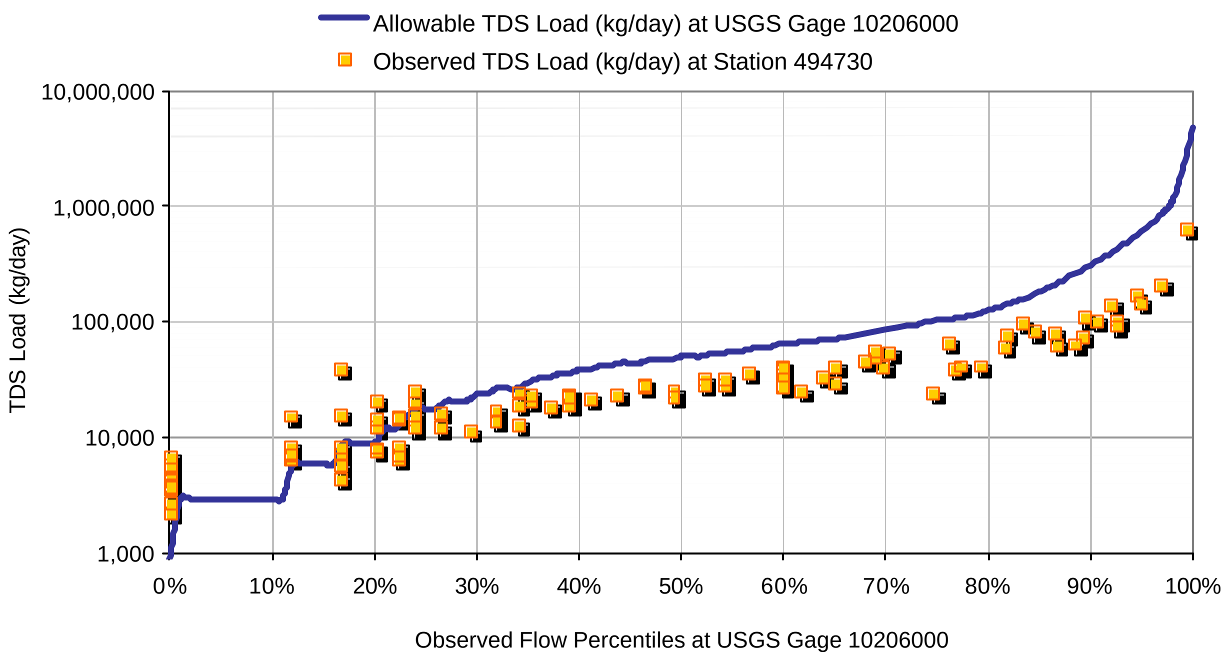

Figure 5-39. TDS Load Duration Curve for station 494730 (US 89 crossing).

Table 5-57. TDS Observed and Allowable Loads for station 494730 (US 89 crossing).

Flow Percentile Ranges	107-Sample Distribution	Median Observed Flow (cfs)	Observed Load (kg/day)	Observed Concentration (mg/L)	Allowable Load (kg/day)	Estimated Reduction (%)	Estimated Reduction (kg/day)
0-10	4	1	5,556	2,271	2,936	47.20%	2,620
10-20	15	2	6,606	1,350	5,872	11.10%	734
20-30	25	6	12,159	828	17,615	0.00%	0
30-40	8	10	18,741	766	29,359	0.00%	0
40-50	9	15	23,218	633	44,038	0.00%	0
50-60	9	19	28,821	620	55,782	0.00%	0
60-70	13	24	38,108	649	70,461	0.00%	0
70-80	7	35	41,465	484	102,756	0.00%	0
80-90	9	61	77,204	515	179,823	0.00%	0
90-100	8	206	143,766	285	604,793	0.00%	0

Sources of TDS in Salina Creek include irrigation return flows and land and streambank erosion. Table 5-58 summarizes the relative magnitude of each of these source categories. The key assumptions used to derive these estimated loads are as follows:

- ?? 500 acres of irrigated crops
- ?? 36 inches water applied per year
- ?? Medium efficiency (50 percent)
- ?? 50 percent of unconsumed irrigation water is returned to the river

Table 5-58. Summary of the sources of TDS loading in Salina Creek.

Source Category	Load	Percent
Land Erosion/Natural Geology	13,886,550	98%
Irrigation return flows	348,210	2%
Total	**14,234,760**	**100%**

The TDS TMDL for Salina Creek is summarized in Table 5-59. Approximately a 6 percent reduction in existing loads is needed to meet the loading capacity. The critical conditions occur during the July, August, and September irrigation period when TDS concentrations peak.

Table 5-59. Summary of the TDS TMDL for Salina Creek.

Expressed as Endpoints					
?? 1,200 mg/L instream TDS concentration					
Expressed as Loads					
Existing Load (kg/yr)	**Loading Capacity (kg/yr)**	**WLA (kg/yr)**	**LA (kg/yr)**	**MOS (kg/yr)**	**Reduction (kg/yr)**
14,234,760	14,077,530	0	13,373,660	703,880	861,100

The recommended BMPs for Salina Creek are listed in Table 5-60. They include practices aimed at increasing irrigation efficiencies and reducing land and streambank erosion.

Table 5-60. Best management practices recommended for Salina Creek.

Practice Number	Practice Name	Intensity Level	Time frame for Load Reduction	Maintenance
221	Seeding	Active	Months – Two Years	Low
450	Irrigation Pipeline	Moderate Engineering	Immediate	Low

Table 5-61 below provides details for one possible implementation strategy. The locally led Sevier River Steering and Technical Advisory Committee will provide guidance and direction for implementation activities needed to achieve the necessary load reductions.

Table 5-61. Estimated impact of one potential set of best management practices for Salina Creek.

Practice Number	Practice Name	Extent of Practice	Estimated Per Unit Load Reduction (kg/yr)	Resulting Load Reduction (kg/yr)
221	Seeding	Seed 1,500 acres to convert barren lands to grasslands	550 kg/yr/acre reduction in TDS resulting from conversion of barren lands to grasslands	825,000
450	Irrigation Pipeline	Install irrigation pipeline for 250 acres, thus increasing efficiencies from 50 percent to 60 percent	150 kg/yr/acre reduction in TDS moving from 40 percent efficiency to 60 percent	37,500
			Total Load Reduction	**862,500**

[1]Estimated load reduction based on lower USLE C-factors associated with grasslands compared to poorly vegetated lands.

5.8 Lost Creek: (Confluence with the Sevier River upstream)

Lost Creek is listed for total dissolved solids. The various land uses found within the buffered stream segment for Lost Creek are displayed in Figure 5-40. The dominant land uses/land cover are sage/grass (28 percent), pinyon/juniper (28 percent), and salt desert (14 percent).

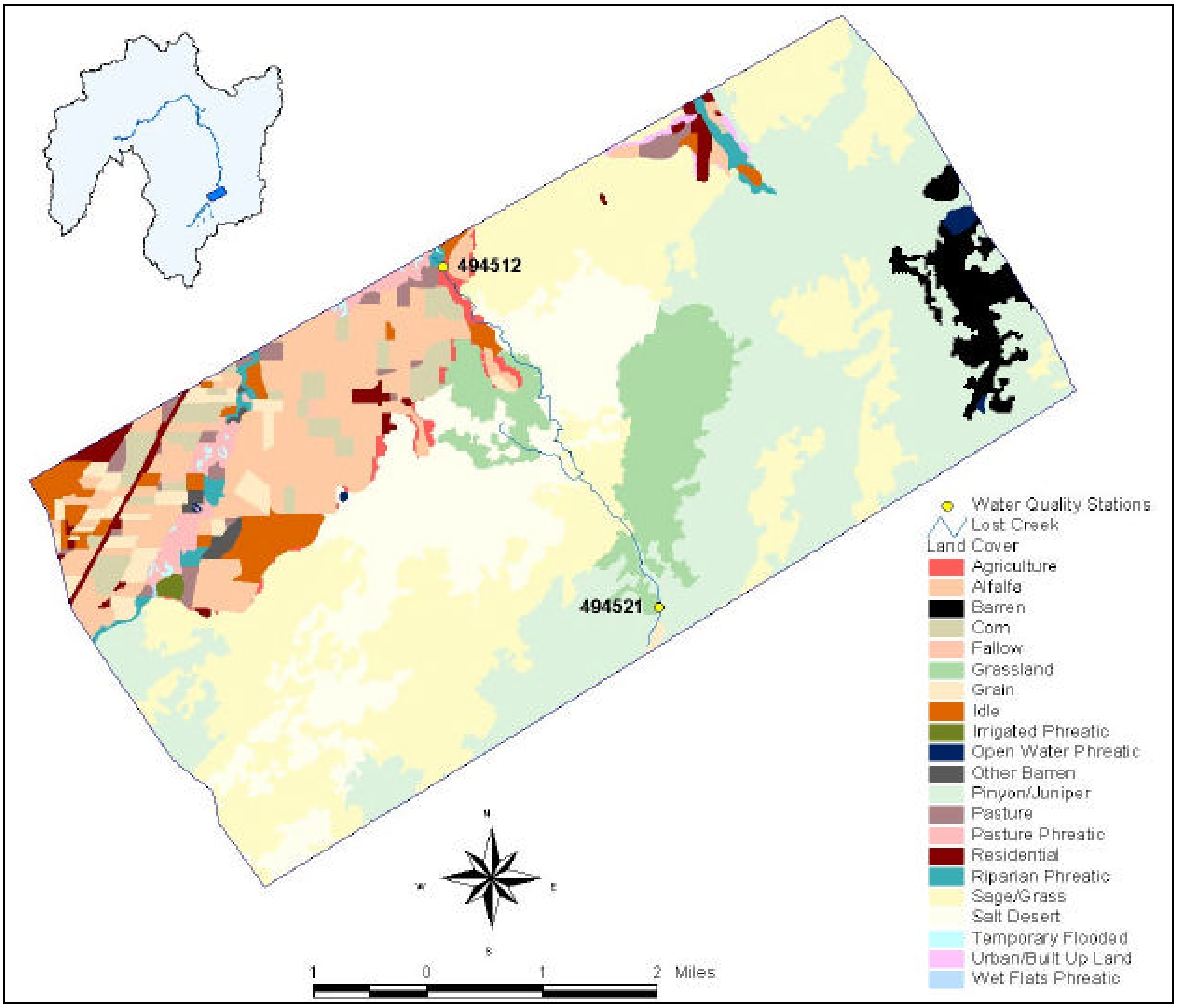

Figure 5-40. Land use and land cover within the buffer zone along Lost Creek.

Recent TDS data are available at 2 stations on Lost Creek (Table 5-62). Forty-six percent of the samples taken at these stations between 1996 and 2002 exceeded the 1,200 mg/L standard. There does not appear to be a seasonal trend in TDS values. Values are greatest in April, July, and August (Figure 5-41). The greatest values are found at station 494512. Six observations at this station were greater than 18,300 (twice the standard deviation) and were therefore deleted from the analysis (per DWQ protocol). There are not enough data to observe any long-term trends in TDS values (Figure 5-42).

Table 5-62. Summary of TDS observations along Lost Creek.

Station	No. of Samples	Average	Min	Max	CV*	Min Date	Max Date
494512 (above confluence with Sevier River)	34	1,731	140	10,868	128%	5/23/78	4/10/02
494521 (at road crossing 4 miles above Sevier River)	34	242	140	395	25%	1/23/80	6/3/97

*CV = coefficient of variation (standard deviation divided by the mean).

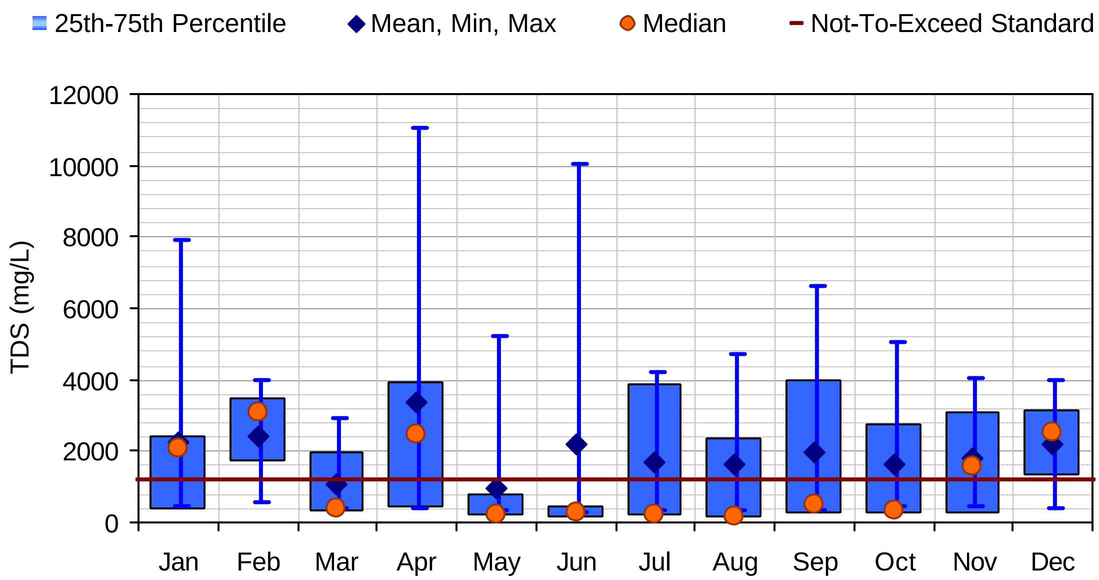

Figure 5-41. Monthly data for stations 494512 and 494521 on Lost Creek. Data cover the period May 23, 1978 to April 10, 2002.

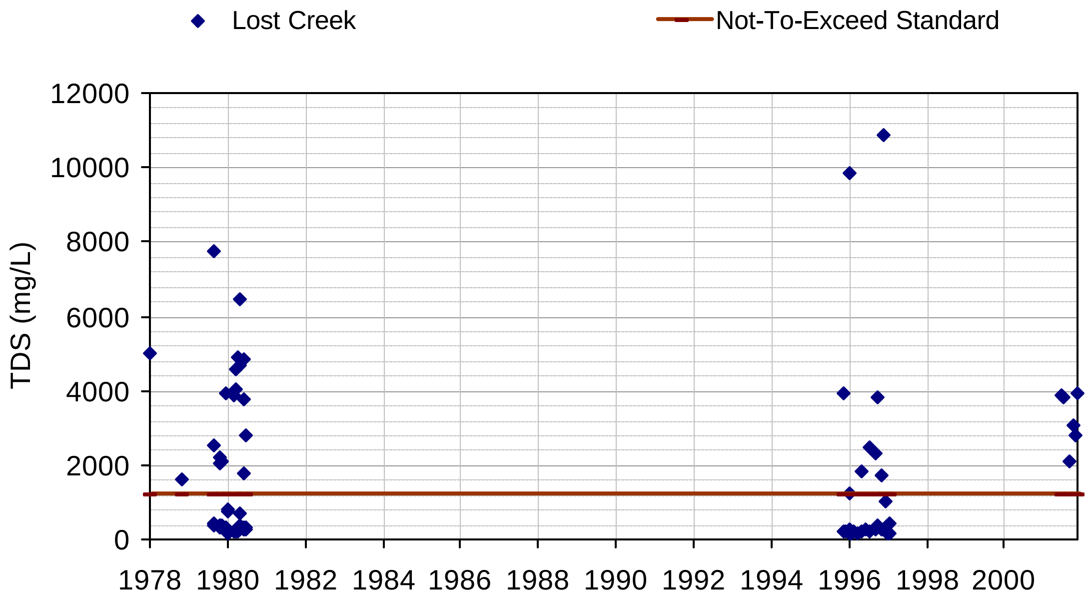

Figure 5-42. All TDS data for stations 494512 and 494521 on Lost Creek.

There are limited anthropogenic sources of TDS in the Lost Creek watershed. There are less than 100 acres of irrigated land that are estimated to contribute no greater than 5 percent of the existing load. The remaining portion of the load is attributed to natural sources. The watershed includes a large area of exposed Arapien shale (see Figure 3-1), which is believed to result in the extremely high TDS concentrations. Therefore a site-specific criterion is recommended for Lost Creek because the statewide target of 1,200 mg/L is not appropriate. Guidance for developing site-specific criteria is summarized in two memorandums issued by EPA. A Region 8 Memorandum (Moon 1997) addressed procedures for Use Attainability Analysis and Ambient Based Criteria, and a memorandum from EPA Office of Science and Technology (Davies 1997) addressed the subject, Establishing Site-Specific Aquatic Life Criteria Equal to Natural Background. These two memorandum were consulted for direction in developing site-specific criteria for the Lost Creek. The applicable points from these memoranda in developing site-specific criteria are:

?? Site-specific criteria are allowed by regulation subject to EPA review and approval.

?? Site-specific numeric aquatic life criteria may be set equal to natural background where Natural Background is defined as background concentrations due only to non-anthropogenic sources.

?? Previous guidance provided the direction to use the 85th percentile of the available representative data for natural ambient water quality conditions.

Data distribution for this station is provided in Table 5-63.

Table 5-63. Summary Statistics for developing site-specific criteria for Lost Creek.

Statistic	Value
Number	82
Mean	1,732
Median	395
Minimum	140
Maximum	10,868
95th Percentile	5,020
90th Percentile	4,522
85th Percentile	3,918
75th Percentile	2,772
Existing Criteria	*1,200*

The 90th percentile, a value of 4,522 mg/L, results in less than 10% exceedences. A 90th percentile also provides some allowance for the minor anthropogenic contribution of TDS. For practical purposes the numeric value is rounded to 4,500 mg/L. A TDS concentration of 4,500 mg/L is therefore suggested as the site-specific criteria applicable Lost Creek.

5.9 Peterson Creek

Peterson Creek is listed for TDS and, similar to Lost Creek, there are limited anthropogenic sources of TDS. There is only one water quality station on Peterson Creek that provides sufficient data for estimating the natural background condition. This data collected from July, 2001 to June, 2002 at Station 494752, Peterson Creek South of Sigurd currently exceeds the water quality criterion of 1,200 mg/l data in 92 percent of the samples. Data distribution for this station is provided in Table 5-64.

Peterson Creek southeast of Sigurd.

Table 5-64. Summary Statistics for developing site-specific criteria for Peterson Creek.

Statistic	Value
Number	12
Mean	5312
Median	4852
Minimum	882
Maximum	10,868
95th Percentile	10,390
90th Percentile	9621
85th Percentile	7,549
75th Percentile	6,058
Existing Criteria	*1,200*

The 90th percentile, a value of 9621 mg/L, results in less than 10% exceedences. A 90th percentile also provides some allowance for the unknown but minor anthropogenic contribution of TDS. For practical purposes the numeric value is rounded up to 9,700 mg/L. A TDS concentration of 9,700 mg/L is therefore suggested as the site-specific criteria applicable Peterson Creek.

5.10 Chicken Creek and Sevier River Tributaries

Chicken Creek and the Sevier River east side tributaries were also listed on the 2002 Section 303(d) list for TDS. However, there are only two data points available for Chicken Creek (1,676 mg/L on June 10, 1980 and 2,640 mg/L on June 2, 1981) and there are limited data available for the east side tributaries (no data since 1988). It is not possible to confirm an impairment based on these limited data and therefore no TMDL is presented for these waterbodies.

6.0 MARGIN OF SAFETY AND SEASONALITY

The Clean Water Act requires that a margin of safety (MOS) be included with all TMDLs. The MOS accounts for any uncertainty concerning the relationship between pollutant loading and receiving water quality. The MOS can be implicit (e.g., incorporated into the TMDL analysis through conservative assumptions) or explicit (e.g., expressed in the TMDL as a portion of the loading) or a combination of both.

The MOS was included explicitly as 5 percent of the loading capacity in all of the Sevier River TMDLs. A relatively low margin of safety was chosen because the load duration curve analysis provides very accurate information on the relationship between pollutant loadings and receiving water quality.

Pollutant loadings in the Sevier River watershed vary seasonally due to variations in weather and source activity. To account for this seasonality, all of the TMDLs presented above present existing and allowable loads by flow percentile, which is a strong surrogate for seasonality (i.e., low flows typically occur in the fall and winter and high flows occur in the summer; see Figure 6-1). The critical months for water quality are also identified in the Sevier River TMDLs based on peak pollutant concentrations, environmental conditions conducive to excessive algal growth, spawning seasons, and likely periods of irrigation. Allocating loads to time periods of similar weather, runoff, and in-stream conditions can help to identify times of greatest impairment and focus TMDL implementation efforts by identifying times needing greater load reductions.

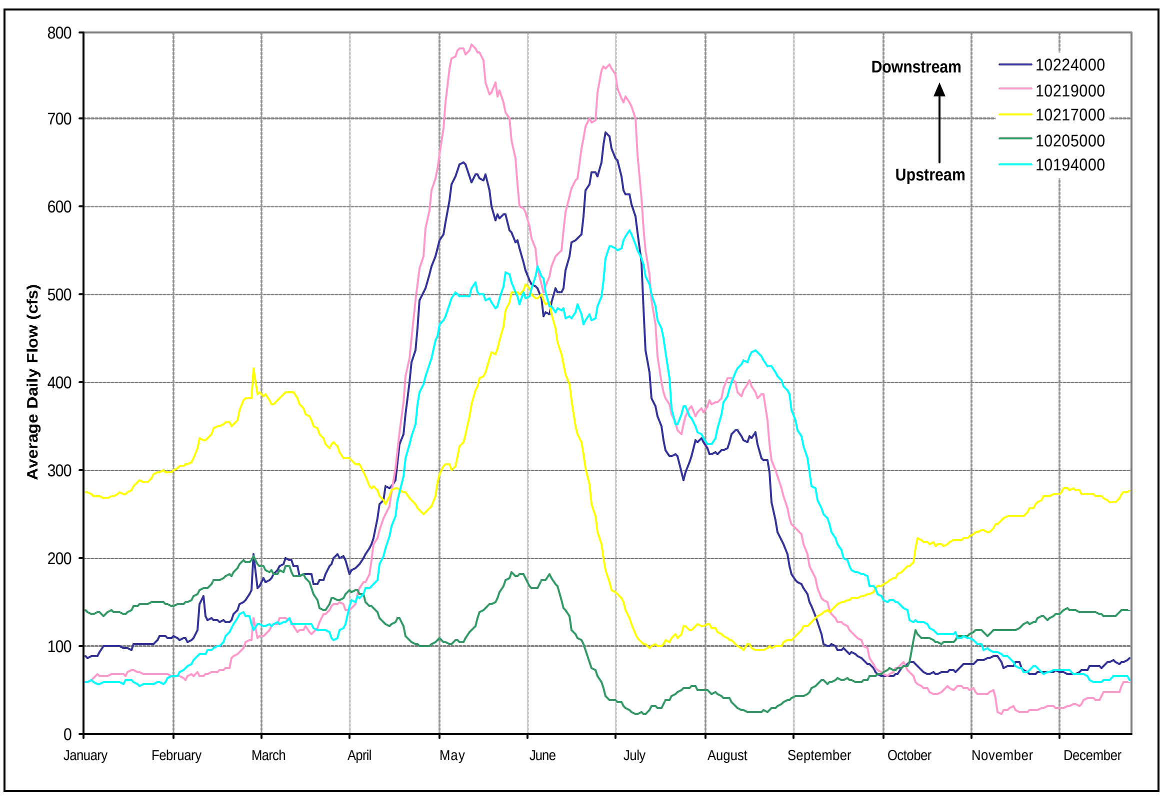

Figure 6-1. Average daily stream flow (cfs) at selected USGS gages on the Sevier River.

7.0 IMPLEMENTATION AND MANAGEMENT STRATEGY

Section 5.0 provides reach-specific recommendations regarding a variety of best management practices to be installed in each listed segment. Information is included regarding load reduction potential, estimated time period for the load reduction to take place, and expected maintenance. Appendix A provides even more detailed descriptions of each practice, including planning considerations, permitting requirements, and potential treatment areas.

The BMPs identified in Section 5.0 have purposefully not been recommended for specific areas of the watershed (e.g., brush revetment should occur from river mile X to Y) because these decisions are best made by the Sevier River Steering and Technical Advisory Committee. The Committee will be meeting to discuss the draft TMDL and at that time more specific recommendations will be identified regarding the potential suite of BMPs to be implemented in each segment. Responsible parties, timelines, and ballpark costs will be estimated at that time.

8.0 MONITORING

An analysis of the Sevier River basin water quality data has revealed several data gaps in monitoring. Although there are numerous established stations in the watershed, few stations have long term monitoring records. Only 28 stations have data for more than 10 years. Several impaired segments in the basin have no recent monitoring data. Recommendations for additional monitoring are listed below.

?? Continue monitoring stations with long-term records on or near impaired segments. These are stations 494110, 494128, 494210, 494247, 494615, and 594411.
?? Begin monitoring impaired segments to obtain more recent water quality data. These segments include Lost Creek, Chicken Creek, Salina Creek, East Side Sevier River tributaries from the Rocky Ford Reservoir to the Annabella Diversion, main stem Sevier River from the Rocky Ford Reservoir to the Annabella Diversion, and the main stem Sevier River from the U-132 crossing to the Yuba Dam. Recommended monitoring stations are shown in Table 8-1 and are based on previous available data and station location.

Three new sampling stations are recommended to better understand water quality in the impaired streams. It is recommended that sampling be initiated at the following locations.

?? Sevier River just below the confluence with Salina Creek and below the Salina wastewater treatment plant.
?? Sevier River east side tributaries from the Rocky Ford Reservoir to the Annabella Diversion.
?? Sevier River just upstream of the Yuba Dam Reservoir.

Table 8-1. Recommended existing stations to begin additional monitoring.

Station	Stream Name
494137	Sevier River
494202	Chicken Creek
494215	Sevier River
494218	Sevier River
494229	Sevier River
494512	Lost Creek
494730	Salina Creek
494805	Sevier River

The source of sediment impairments was difficult to determine during the development of these TMDLs. Sediment in streams can originate from several possible sources that include upland erosion, scouring, bank erosion, mining, and agricultural practices. It is recommended that DWQ install bank erosion pins in several places of each listed stream segment to more accurately quantify the load from this source.

Finally, additional biological data would help determine a better set of targets for sediment and total phosphorus. It is recommended that DWQ begin to collect annual benthic macroinvertebrate data at several stations along the Sevier River. Potential stations to collect these data include those stations with long-term water chemistry data near impaired segments. These are stations 494110, 494128, 494210, 494247, 494615, and 594411. Potential reference reaches should also be identified and annual sampling should initiate at these sites.

9.0 PUBLIC PARTICIPATION

In Utah, the development of TMDLs is integrated within a larger watershed management framework that emphasizes a common-sense approach aimed at protecting and restoring water quality. Key elements of this approach include:

?? Water quality monitoring and assessment
?? Local stakeholder leadership
?? Problem targeting and prioritization
?? Integrated solutions that coordinate multiple agencies and interest groups.

The Sevier River Steering and Technical Advisory Committee has been involved with the development of the TMDL through their participation in several meetings at key junctures in the project:

?? Project Kickoff Meeting on June 25, 2002
?? Source Assessment Meeting on June 11, 2003.

Members of the Committee, and other watershed stakeholders, have also been involved with the development of the TMDL through their participation in efforts to compile available information. Stakeholders that have provided information critical to the successful development of this TMDL include the following:

?? City of Richfield
?? City of Salina
?? Deseret Irrigation Company
?? Richfield Irrigation Company
?? Richfield Natural Resources Conservation Service
?? Several individual landowners
?? Utah Farm Bureau

A final Committee meeting will be held in the spring of 2004 to discuss the draft TMDL report and identify specific implementation strategies. Due to the large scale of the watershed and the complexity of the issues, the Committee will be assisting DWQ with problem targeting and prioritization of solutions, especially for nonpoint sources. Other agencies that will be involved in identifying solutions in the watershed include the Natural Resources Conservation Service (NRCS), the Bureau of Land Management (BLM), and the local municipalities and landowners.

10.0 REFERENCES

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